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This compendium of ninety papers given at the first Programed Instruction Institute of the National Society for Programmed Instruction (NSPI) attempts to define what programed instruction is, to show what it is accomplishing right now in many fields of endeavor, and to develop a plan for its future use. The papers center on the theme of the practical application of programed instruction and are organized to reflect trends in areas of social importance such as education, industry, the military, government, and medicine. The role of the teacher in the presentation and development of programed instruction is examined, and its possible applications to the exceptional student are outlined. Instructional programing, the development of systems applications, and program evaluation are discussed. A bibliography is appended. (BB)

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Trends in Programmed Instruction

PAPERS FROM THE FIRST ANNUAL CONVENTION OF
THE NATIONAL SOCIETY FOR PROGRAMMED INSTRUCTION

EDITED BY
GABRIEL D. OFIESH
AND
WESLEY C. MEIERHENRY

THE DEPARTMENT
OF
AUDIOVISUAL INSTRUCTION
NATIONAL
EDUCATION ASSOCIATION
AND
THE NATIONAL SOCIETY
FOR
PROGRAMMED INSTRUCTION

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
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TRENDS IN PROGRAMMED INSTRUCTION

Papers from the first annual convention of the National Society for Programmed Instruction.

edited by

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National Education Association
and
National Society for Programmed Instruction

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Foreword

This publication is a very significant cooperative effort of the Department of Audiovisual Instruction and the National Society for Programmed Instruction. It is, we believe, a harbinger of future joint activities between our two organizations whose purposes converge in the field of programmed learning.

Since 1923 the Department of Audiovisual Instruction of the National Education Association has been a major source of information to the teaching profession on what has recently come to be known as educational technology. Through its magazine, *Audiovisual Instruction,* its quarterly journal, *AV Communication Review,* and its dozens of other publications, DAVI and its 6,000 members have worked diligently to improve instruction through the more effective use of all educational media in the teaching-learning process. More recently the National Society for Programmed Instruction, described in the Preface, has become a significant source of information on programmed learning with its journal and its convention.

It seems most appropriate that DAVI and NSPI have joined together to produce this important volume for their own members, for the teaching profession, and for all those interested in this promising new instructional technology.

On behalf of the members of both DAVI and NSPI, we want to take this opportunity to express our gratitude to the editors of this volume. Both Col. Ofiesh, editor, and Dr. Meierhenry, associate editor, have worked tirelessly with both insight and dedication to make this book a reality. Members of the NSPI Editorial Board have each made important contributions and we want to express our thanks to each of them: David M. Wark, William A. Deterline, Carlton B. Downing, M. C. Zaccaria, Charles F. Adams, A. J. Bouck, I. J. Newman, and John R. Olsen.

Finally, we extend thanks to those who wrote this book, the distinguished group of authors and pioneers, whose papers we are pleased to publish.

WILLIAM H. ALLEN, President
Department of Audiovisual Instruction,
National Education Association

ROBERT G. SMITH, Jr., President
National Society for Programmed Instruction

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I. J. Newman
Gabriel D. Ofiesh
John R. Olsen
David M. Wark
M. C. Zaccaria

Preface

In the first week of January, 1962, eight individuals interested in programmed instruction met. Although most of these individuals were given to great flights of imagination and expectations, none expected that a National Society for Programmed Instruction would be formed as a result of their activities. Certainly none expected that such a national society would hold its first convention in San Antonio participated in by the most prominent names in the field of programmed instruction, and which has resulted in the preparation of this present volume, just a little more than a year and a half after this original meeting.

The original eight along with thirty-two other individuals met in February, 1962, at Randolph AFB, Texas, to found the National Society for Programmed Instruction whose purpose was to "collect, develop and diffuse information concerned with programmed instruction." The original group represented a cross-section of San Antonio Military, Public School and University education and training officials. The group elected Colonel Gabriel D. Ofiesh, USAF, as its President, Dr. Carlton B. Downing, Trinity University, Vice President, Colonel Marian A. Tierney, USA, Secretary, and Dr. Michael A. Zaccaria, Psychologist, Treasurer.

At this first meeting the President spoke of the resistance meeting the introduction of programmed instruction. This resistance he felt was largely the result of ignorance and misinformation about programmed instruction. He charged the members of the society with the responsibility to spread and inform the public about the potentialities of programmed instruction and to dispel both ignorance and misunderstanding.

On April 14, 1962, the National Society for Programmed Instruction (NSPI) presented the first "Programmed Instruction Institute" in San Antonio, Texas. The institute, held at Trinity University, was presented to introduce the "why," "what," and "how" of programmed instruction. The audience was a heterogeneous one, ranging from sophisticated research psychologists to insurance salesmen curious about the "teaching machine" business. The speakers and discussion leaders tried, and admirably succeeded, in presenting something for everyone.

In the first paper of this institute, NSPI's president pointed out three nation-wide problems of modern education: high-school dropouts, industrial retraining, and teacher procurement. He suggested that programmed instruction may be the first step toward a partial solution to some of these problems. Cautiously, however, he put the new techniques into perspective, balancing the proposed solutions against some of the adverse effects they may have on education, training and our total society.

The papers contained in this volume are, among many things, a record of those who labored, unceasingly and without formal recognition, to make NSPI a truly national society. We should like to express our sincere appreciation to the authors of the papers for granting permission to make slight editorial revisions as well as condensations.

A special word of appreciation is due the Department of Audiovisual Instruction (DAVI) of the National Education Association. We wish to express our sincere appreciation for the whole-hearted support and encouragement provided by the entire DAVI staff. Specifically to be commended in this respect is Dr. Robert C. Snider, Assistant Executive Secretary of DAVI. From the very beginning of this venture, he has encouraged the idea of a joint publication of these proceedings. Throughout the editorial phases of the production of this book, he provided us with constant guidance and assistance. Without his moral and emotional catalytic support, it is doubtful that this publication would have become a reality. Lastly, the editors wish to express their deep and sincere debt to Lt. Charles F. Adams and Mrs. Peggy Langner, for their untiring efforts over the entire period of the convention, and who, during preparation of this volume, worked many long hours and supervised the work of others in the preparation of the intermediate drafts of all the papers. It is our hope that this will be only the first of a series of volumes which in the years to come will define future trends and innovations in instructional and educational technology.

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THE CARPENTRY REVOLUTION—A FABLE*

W. A. Deterline

Once upon a time carpentry was a very frustrating business which depended on tools that rarely produced products of consistent quality. Carpenters labored hard with what they had, but their products were accepted only because there seemed to be no possibilities of doing any better. Then one day a man who was not even a carpenter invented a tool he called a "plane" and he suggested that carpenters could use it to great advantage in their work. No one listened to this man, of course. Some years later another who was not a carpenter either, invented a device he called a "saw" and he made quite a bit of noise about his device and its potential in the carpentry business. Another man (also non-union) at about the same time invented a "hammer" and he too made noise that attracted attention. Each of the three men attracted followers, some of whom were cooks and hunters and golf pros. Then a peculiar thing happened. Instead of providing a useful set of tools for the carpenters, the "saws" and the "planes" and the "hammers" argued among themselves over which tool was best. The "saws" said, "Our tool works on wood better than a hammer or a plane," and the hammers said, "Our tool hits nails and thumbs better than a saw or a plane", and the planes, well you know what *they* said. Then other voices were heard extolling the virtues of screw drivers, rasps, drills and all manner of other strange tools and furious controversies were waged over the question of who had the *one tool* that would solve all of the carpenter's problems. A few unaware types tried using combinations of several tools, but they were quickly hooted out of town for their lack of imagination. The carpenters waited and waited for the dust to settle so they could welcome the winner with a ticker-tape parade, but lost patience as the bickering continued and finally just shrugged their shoulders and went back to work. Since everybody in the new tool missionary profession was so involved in his own little sphere of interest, the whole business finally collapsed. The cooks went back to cooking; the hunters went back to hunting; silence feel in the land. Several centuries later someone stumbled onto the records of the old controversies. After laughing at the silliness and futility of it all, he put together a highly flexible and effective tool kit that made carpentry the science it is today. Then many people lived happily ever after some of the time.

MORAL: Our classrooms could have had comfortable seats sooner if someone had kept his eyes on the end not the means.

---

* The fable as a communications device was first used objectively by the Aesop of programmed instruction, Dr. Robert F. Mager.

I Introduction

Gabriel D. Ofiesh, Colonel, USAF

As we run down the list of education and training problems confronting us today, we might well feel we were marooned on an island of problems surrounded by a sea of despair. But when I look at this sea of despair surrounding this island, I am reminded of the story that I read a few days ago, which is attributed to Gilbert Keith Chesterton and which may be apocryphal. Chesterton was asked one day to answer the profound question that, if he were marooned on an island with no hope for survival, what is the one thing he would want above all things, if he had his choice. He answered very practically, "I think I would ask for a copy of Jame's text on Practical Ship Building." Now, being as deeply a religious man as he was, it is interesting that he didn't ask for a message, or a panacea. He didn't ask for the Bible or for a miracle. Self-confident in his relationship to his God, he simply asked for a means to survival.

This anecdote illustrates the need for realistic innovation in most trying circumstances. We are on the threshold of radical innovation in the field of education. Programmed instruction has emerged as simply a vehicle through which this educational innovation may make substantial strides. John Gardner, President of the Carnegie Corporation, in his Annual Report last year (Gardner, 1962) had the following comments to make about innovations which are pertinent to those of us who would innovate in education in our society today:

> To accomplish renewal, we need to understand what prevents it. When we talk about revitalizing a society, we tend to put exclusive emphasis on finding new ideas. But there is usually no shortage of new ideas; the problem is to get a hearing for them. And that means breaking through the crusty rigidity and stubborn complacency of the *status quo.*
>
> The development of resistance to new ideas is a familiar process in the individual. The infant is a model of openness to new experience, receptive, curious, eager, unafraid, willing to try anything. As the years pass these priceless qualities fade. He becomes more cautious, less eager, and accumulates deeply rooted habits and fixed attitudes.
>
> The same process may be observed in organizations. The young organization is willing to experiment with a variety of ways to solve its problems. It is not bowed by the weight of tradition. It rushes in where angels fear to tread. As it matures it develops settled policies and habitual modes of solving problems. In doing so it becomes more efficient, but also less flexible, less willing to look freshly at each day's experience. Its increasingly fixed routines and practices are congealed in an elaborate body of written rules. In the final stage of organizational senility there is a rule or precedent for everything. Someone has said that the last act of a dying organization is to get out a new and enlarged edition of the rule book.
>
> And written rules are the least of the problem. In mature societies and organizations there grows a choking underbrush of customs and precedents. There comes to be an accepted way to do everything. Eccentric experimentation and radical departures from past practice are ruled out. The more pervasive this conventionality, the less likely is the innovator to flourish. The inventor of the Bessemer process for steel making, Sir Henry Bessemer, wrote:
>
> > 'I had an immense advantage over many others dealing with the problem inasmuch as I had no fixed ideas derived from long established practice to control and bias my mind, and did not suffer from the general belief that whatever is, is right.'
>
> As a society becomes more concerned with precedent and custom, it comes to care more about *how* things are done and less about *whether* they are done. The man who wins acclaim is not the one who "gets things done" but the one who has an ingrained knowledge of the rules and accepted practices. Whether he accomplishes anything is less important than whether he conducts himself in an "appropriate" manner. Thus do men become the prisoners of their procedures.
>
> . . . New developments in a field often originate outside the area of respectable practice. The break with traditional art was not fostered within the Academy. Jazz did not spring from the bosom of the respectable music world. The land-grant colleges, possibly the most impressive innovation in the history of American higher education, did not spring from the inner circle of higher education as it then existed. Motels, the most significant development of this generation in innkeeping, were at first regarded with scorn by reputable hotel people.
>
> Vested interests constitute another problem for the aging society. The phrase "vested interests of workers" may be as strong as those of the top executives. In any society many established ways of doing things are held in place, not by logic nor even by habit, but by the enormous restraining force of vested interests. In an organization certain things remain unchanged for the simple reason that changing them would jeopardize the rights, privileges, and advantages of specific individuals, perhaps the president, perhaps the maintenance men.
>
> The more democratic an organization or a society the more clearly it will reflect the interests of its members. So a democratic group may be particularly susceptible to the rigidifying force of vested interest.
>
> Still another reason for the loss of vitality and momentum in a society is a lowered level of motivation. It is not always easy to say why motivation deteriorates. Perhaps people stop believing in the things they once believed in, the things that gave meaning to their efforts. Perhaps they grow soft from easy living. Perhaps they fall into the decadent habit of imagining that intense effort is somehow unsophisticated, that dedication is naive, that ambition is a bit crude. Or perhaps a rule-ridden society has bottled up their energy, or channeled it into all the tiny rivulets of conformity.

> One may argue, as Toynbee does, that a society needs challenge. It is true. But societies differ notably in their capacity to see the challenge that exists. No society has ever so mastered the environment and itself that no challenge remained; but a good many have gone to sleep because they failed to understand the challenge that was undeniably there.
>
> Whatever the reason for loss of motivation, the consequences are apt to be devastating. Nothing, neither wealth nor technology, neither talent nor wisdom, will save a society in which motivation continues to deteriorate.

Dr. James W. Laurie, President of Trinity University, in his welcoming remarks at the first annual meeting of the National Society for Programmed Instruction also pointed out the need for realistic innovation when he said:

> Most of us are aware of the fact that information is accumulating at such a fast pace that it becomes mandatory that we seek out new methods just to cope with the acquiring and dissemination of new knowledge as it crowds upon us in almost every field.

And then later in his remarks he stated:

> . . . Any program that will speed up our task and sharpen the best brains of the future, more wisely and rapidly, deserves the very careful assessment of everyone who says he believes in education. As a matter of fact, I think (those attending this convention are) dealing in this area with the essence of academic freedom. As an educator, I see that the administrator or the professor who talks loudly about academic freedom is often one who expresses fearfulness when any new technique or new procedure is suggested to him, but clutches to himself only those timeworn methods with which he is most familiar. It is the essence of academic freedom to be unafraid of new truths, and new methods, and new ways. I for one, and I think I speak for my colleagues on the hill, for the other educators in this great community, am eager and ready to listen to anything you have to say to us that will enable us to do our job more effectively, more wisely, and more completely. "... It should not be required of you to give us all the answers; it will be necessary that you give us some. . . . I do not think you need to defend the theory any longer. I do believe it is important for you to tell what programmed instruction is actually doing, what it's accomplishing, what it's achieving, and what you propose to have it do.

After these few challenging keynote comments to the conference participants, President Laurie went on to point out in rather critical, but realistic and hopeful terms, that he had no illusion that programmed instruction was "ever going to replace the professor". However, he did point out that this would be small consolation to some because:

> . . . Now some are going to be replaced simply because they have a sheer inability at keeping up with the stream of knowledge in their field. Some are going to be replaced because they're not willing to pay the terrific price of assimulating this new knowledge that comes their way. Some are going to be replaced because they are not sufficiently addicted to academic freedom to be willing to try to understand any thing new. But most of them, at least the majority of those that I know, will be stimulated and aided by what you're doing and will add to their repertoire of skills and techniques and methods some of the fruits of your labors.

The papers in this volume, which reflect the comments made by the many participants in the conference, are a partial answer to Dr. Laurie's challenge to "tell what programmed instruction is, what programmed instruction is actually doing, what it is accomplishing, what it is achieving, and what (we) propose to have it do." It is for this reason that the present volume is called "Trends in Programmed Instruction". The papers were organized to reflect trends in a variety of areas such as: Education; Development of Systems Applications; Impact on the Teacher; The Exceptional Student; Industrial Applications; Military and Governmental Applications; The Health Sciences; Instructional Programming; Evaluations; and Future Trends. Finally, Dr. Meierhenry's chapter "A Point in Transition", weighs the parameters for future lines of consideration.

Even though programmed instruction has not produced the startling revolution in education that was predicted for it several years ago by many of its ardent and enthusiastic adherents, a review of the developments at the first conference of the National Society for Programmed Instruction certainly leaves no question but that programmed instruction has at least emerged as a truly formidable system of instructional technology. It has raised many questions about instructional methods that have been undoubtedly raised before, but which today have hope of being realistically answered.

A need for a revolution in educational processes is still a necessity for our "Atomic and Educational Age of Anxiety". Even though the results of programmed instruction have not been revolutionary, the efforts certainly could not be characterized in the same evolutionary tones as for other educational developments which have been simply evolving for centuries. Through programmed instruction we have, at the very least, arrived at the threshold of a revolution which in the years to come may take some very unanticipated forms. The efforts of the present state of programming are primitive, at best, but they are efforts, and unusual ones at that.

Automated instruction with its correlative technology still promises the first true and radical innovation in instruction since the invention of movable type. This is not to gainsay that there have been vast social developments which have had an extensive impact on education. Education has been extended to millions who would not ordinarily benefit from it. Radio, television, and other mass media of communication and propaganda have had their undeniable effects. There have been significant advancements in the design of school buildings. Despite these and many other developments, the fact still remains that there has been no revolutionary breakthrough in the processes of education and training. There has been no radical advances in instructional theory, methods, or in the development of procedures by which people can learn more rapidly and more effectively.

In spite of the numerous education and training problems confronting us in our society today, there has been no significant effort to provide hopeful solutions. The problems, on the other hand, are too numerous to mention. The newspapers reported last year that in this year alone almost a million lost, bewildered, hopeless youngsters will leave school before graduation and enter a world which really has no place for them. Dr. Daniel Schrieber, Director of the School Drop-Out Project of the National Education Association characterized these youngsters as "constantly running from work half-done, from school half-completed, . . . truly fugitives from failure."

The problems surrounding the impact of technology and automation bombard us from all points of the cultural compass. We have a state of overemployment in our unskilled labor ranks and underemployment in our skilled trades. How we are going to solve these problems will in all likelihood determine our future as a nation.

Judge Mary Kohler, a member of the late President Kennedy's National Committee on the Employment of Youth, has emphasized that in 1960, of the 2,500,000 youngsters who reached 18, roughly one-third went to college, one-third quit school after graduation, and one-third had dropped out. More than one and one-half million of these youngsters did not have an organized plan to take them from school to a job, that would be satisfying to themselves or that would enable them to make any significant contribution to society. Dr. Conant has pointed to the "social dynamite" inherent in this situation. Throughout the country in the past year the demand for jobs on the part of late adolescents has increased nearly seven times and the supply has only doubled. Cities throughout our nation are reporting drastic decreases in jobs available to sixteen and seventeen-year-olds.

There is a national awareness of the retraining problems that have been created by the impact of automation. The problems concerning retraining have been more easily stated than solved. These problems are not going to be solved by simply cataloguing the number and types of jobs which need to be filled with skilled workers and then establishing training programs for the unemployables to enable them to fill these jobs.

In discussing our training problems as a nation, Congressman Henry B. Gonzales, who gave the keynote address at the first annual conference of NSPI, pointed out in rather vivid terms the stake that the country has in human resources that are not adequately trained. The following excerpts from his keynote remarks stress in strong terms the need for educational innovation and the hopeful note that programmed instruction offers without being necessarily the ultimate answer:

> . . . The Federal Government, which is only a very junior partner in the total educational endeavors of this Republic, spends something in excess of 1,938,155,985 (almost 2 billion dollars!) a year right now for teaching functions. This does not count the costs of training its own employees or military personnel for most governmental positions, but is simply an estimate of what is now budgeted for teaching functions to citizens.
>
> . . . It is used here to give some measure of why the government has a direct interest in the work you are going.
>
> . . . The Manpower Retraining Program is still a fledgling. It is now established public policy that we have a commitment to help raise the skills, the literacy, the abilities of the American people. We have this commitment to help soften the dislocations and impact of this thing called automation; we must exert ourselves in this area to lessen the costs and debilitating affects of our welfare rolls, our unemployment lines, our undeveloped human resources.
>
> . . . I can conceive of reaching a saturation point on many things prominent in our culture: automobiles, food, houses, even clothes. But I cannot even conceive of a saturation point on human learning, on educational opportunities, on teachers themselves. Other jobs may disappear, other tasks may be removed, but our commitment to learning must by the very nature of our world expand and keep on expanding. But the point is obvious: With a limitless need, we acquire a limitless outlet for the techniques you (NSPI) are developing.
>
> . . . This is an exciting thing you propose. I have enough wisdom, I believe, to know that it is not the only approach to educating, nor is it necessarily the last word or the best word even in the area where applied. What is exciting is that the teachers themselves are finding new ways to apply their art.
>
> . . . There is a ferment in educational circles today. There is much talk of and about methodology, of tools, of content. This is good. This bodes well for our future. I suspect out of this ferment will come the means of dealing with our future. We should not be dismayed because there is not unanimity on the proposals being made. How can there be when the form of our future is itself unknown? For this reason, if none other, we need to have new techniques applied to maintain the highest possible flexibility to meet the many unknown factors in the equation of our times which inexorably will balance what we get out of life with the efforts we put in.

There was noted a sense of cautious urgency in the Congressman's remarks. It should be emphasized, however, that there is no "crash program" that can possibly deliver us from our dilemma. We are already a nation with a shortage of 150,000 teachers. Many of our teachers are non-college graduates having substandard credentials. The number of able and master teachers among those who have paper qualifications and college degrees is woefully low. Teachers, as a group, still have a long way to go in developing an extremely high professional status. This is largely due to the fact that they lack, at present, a true instructional technology. Many of them work under impossible conditions which prevent them from making most effective use of their talents and skills.

The problem, as it appears at present, will get worse, not better. Within another three years alone we will increase our present school enrollment by five and one-half million students. Our teacher shortage will grow to over 300,000. To merely maintain the status quo, over one-half of all our college graduates during the next five years would have to become teachers. This is a most unlikely prospect. One of our Midwestern states anticipates a 45% increase in college enrollment during the next two years. We are likely to react to this problem by stressing quantity over quality and by reducing still further our teacher qualifications.

Ours is an age in which our knowledge of man and his universe is doubling every decade. It has been pointed that there have been more discoveries in the field of mathematics during the last decade than there have been in all the previous history of civiliation. Our educational technology has not been able to keep up with the innovations of technology itself. We must turn with hope to the belief that the problems created by technology will be solved by technology. Can instruction truly become a science? Can the science of learning be applied to the art of pedagogy? Technology is the application of science to art. Can the studies of the behavioral scientist concerning the fundamental processes of learning be applied to the practice of education and instruction? If instruction must remain an art and never become a technology, what is our alternative? And ultimately, will our desperate need for an instructional technology be sufficient in and of itself to force the issue?

The late President John F. Kennedy, in a recent message to Congress (1962) emphasized that:

> No task before our nation is more important than expanding and improving the educational opportunities of all our people. . . .

He further pointed out in his message:

> . . . education is both the foundation and the unifying force of our democratic way of life—it is the mainspring of our economic and social progress—it is the highest expression of achievement in our society, enabling and enriching human life. In short, it is at the same time the most profitable investment society can make and the richest reward it can confer. Educational failures breed delinquency, despair, and dependence. They increase the costs of unemployment and public welfare. They cut our potential national economic output by billions. They deny the benefits of our society to large segments of our people. They undermine our capability as a nation to discharge world obligations. All this we cannot afford—better schools we can afford.

> . . . We must provide facilities for fourteen million more elementary, secondary school, and college students, by 1970, an increase of thirty per cent. . . . We must find the means of financing a seventy-five per cent increase in the total cost of education—another $20 billion a year for expansion and improvement—particularly in facilities and instruction, which must be of the highest quality if our nation is to achieve its highest goals.

Here, again, although all the measures mentioned by the late President are undoubtedly necessary, they will fall short unless some means is provided for making a breakthrough in the processes by which some teach and others learn. If an infinitesimally small part of the effort recommended were to be expended in developing a true educational technology, then the tools might be forthcoming by which we might make a momentous step forward in the solving of our problem.

What has all this to do with programmed instruction and the deliberations of the conferees of the first annual convention of the National Society for Programmed Instruction? There has been no development in education that has provided as hopeful a sign for the revolutionary emergence of such an educational technology as was started by the efforts of Dr. Sidney Pressey some 35 years ago and so dramatically revitalized by Dr. B. F. Skinner a few years ago at Harvard. It is this development, which has been referred to as programmed instruction or automated teaching, which relates the deliberations of the first annual conference of NSPI to the need for educational innovation.

The interest in programmed instruction has been accompanied by much apprehension, anxiety, and talk about automation, automated instruction, and teaching machines. George Kneller (1961), in his address before the American Psychological Association, stated the issue very succintly when he commented in his opening remarks that:

> Whether we like it or not, automated teaching is here to stay. Merely to oppose it is futile. Education must mirror the age it strives to improve. It cannot isolate itself from automation any more than from other social or economic changes. For automated teaching is one more of the applications of technology to human life. The question to be asked is not, 'Do we accept automation?', but 'How much of it and under what condition?'.

What has programmed instruction to do with automated teaching, and specifically with teaching machines? We have heard over and over again that teaching machines do not teach. It has been pointed out by many that they merely present materials which have been developed, or programmed as we now say, in a special way. Many have claimed that teaching machines are simply a device which presents stimuli and provides for active responses from the student. Many teachers are often merely stimulus machines. They cannot provide for active student response except in a tutorial relationship, which is impossible to develop with every student in a lock-step situation involving 20 or 30 students. Whether this will remain so in the years to come will only be answered by further developments in teaching machine technology. The following clarifying comment from Dr. Robert Mager (1962) deserves mention:

> When one says that 'Teaching machines do not teach,' the implication apparently is that teachers *do* teach. The problem, I suppose, is with the meaning of the word 'teach.' If a teaching machine is a thing that presents information to the learner and adjusts itself on the basis of the learner's response, then so does the teacher. As a matter of fact, the machine can be far more effective than the teacher in presenting information in an appropriately organized fashion, and in accommodating itself to the needs of the individual learner. If you mean to imply that the difference is one of function, and that the teacher does something *more* than simply present the program, then you might say this rather than that machines don't teach but teachers do. While instructional devices that do more than simply present the program do not abound, they do exist and will become considerably more sophisticated as time goes on. Whether a device can or *should* be able to do anything a teacher does is another matter.

One cannot argue at this time, however, with the contention that the manner in which the information is prepared to go into the machine, the size of the increments of the information presented, the sequence of the information, and how the student responds to the materials throughout the program, determine how effective the machine really is. This content and the manner in which it is prepared is called "the program", and for this reason "the program" is the heart of any teaching machine. The "program", for that matter, is the heart of any teacher—human or machine.

Good teachers have always known that their basic function was to communicate effectively with students. They have always known that they must determine how effective or ineffective their communication has been before they modify what they have done. Their modification was based on knowing where, how, and why they had failed in the communication process. They did this by listening to the student. Until the loop was closed they were not able to determine whether instruction had taken place. Good teachers have always known that very few students learn very many specific facts from teachers. They have perceived their role as motivating students to acquire much knowledge from reading, studying, analyzing, and cogitating. Good teachers inspire, motivate, and illuminate. They don't teach facts. They teach students. They do this best in one specific kind of student-teacher relationship, the tutorial relationship.

It is obviously impossible for every teacher to be a tutor for every student. We will never be able, no matter how fine our intentions, to establish a tutorial relationship between a master teacher and every student in every classroom in this nation. Some means must be found to mass produce the elements of the tutorial relationship so that very student at his own level can have quality instruction.

Programmed instruction is the first step in an effort to do this, an effort to package for all students the characteristics of the tutorial approach!

By programmed instruction the student is led "one step at a time" along the learning path. He actively responds to a curriculum that has been logically sequenced so that his response *always* carries him a little closer to the ultimate desired learning outcome. The student is required to respond to questions, solve problems, or complete exercises. Whenever the student makes a response he is *immediately* informed how correct or accurate his answer is and, where necessary, provided with additional information to correct his answer. It is this aspect of programmed instruction which comes the closest to approximating the tutorial relationship.

The ideal program, according to Skinner, would be one where the student would make no errors whatsoever in his responses. To accomplish this goal, the information is presented to the student in very small steps, and he is steadily cued, or prompted, in such a manner that he cannot help but make the correct response. Learning becomes almost effortless, *but not thoughtless,* and it is meant to be that way. Every response made by the student is an overt as well as a covert one. It is the nature of the constructed response on the part of student (i.e., filling in a blank, drawing a diagram, solving a problem, writing a word, etc.) which determines the extent to which he participates *actively* in the learning program. After he constructs the correct response he immediately knows whether or not he is correct, and this knowledge, or feedback, is supposedly reinforcing. The burden is on the program, however, to lead the student to construct the correct response in such a manner that he learns by doing so.

All programmed materials are crucially dependent on another prior step which experience has shown is probably the most important aspect of this technology. This is the "task" or "learning outcome analysis." Traditional descriptions of learning objective have been most inadequate. Such learning outcomes or job training standard elements as "Be familiar with, . . ." "Understand the . . . ." "Operate the . . . ." and "Repair the . . . ." are not good enough. The analysis of learning outcomes, which initially guides the development of the programmed instruction materials, must be intensive, extensive, and specific. Learning outcomes must define as completely as possible what performance the student is expected to demonstrate at the termination of the program. The terminal behavior desired at the conclusion of the program must be stated in concrete and explicit terms. There can be no misinterpretation by anyone as to the nature of the desired learning outcomes. It has been said that this condition is desirable for all education and training programs. True. It is impossible, however, to develop an adequate programmed instruction package without this. Programmed instruction *forces this issue* like no other instructional technology we have developed.

In summary then, what are the salient features of programmed instruction?

1. The program begins with a specific description, in behavioral terms, of desired learning outcomes.
2. The program is a carefully and logically arranged sequence of information.
3. The student is required to be an active participant throughout the program.
4. The program is arranged so that every student can proceed at his own individual rate.
5. The program must provide the student with immediate knowledge of the correctness of his responses.

In the past, when students did not learn, and materials of learning were not easily understood, we rarely if ever blamed the teacher or the textbook writer. The student more often than not was to blame. Either he was too stupid or too dense to understand our "simple" explanation or—and this has been a recent explanation in explaining away our failures as teachers—he was improperly educated by other teachers or schools.

In programmed instruction an entirely new concept of responsibility enters the learning situation. The burden of responsibility for the student learning is on the program and the instructional technology used—not solely on the student. If the student doesn't learn, something is wrong with the program. It must be thrown out and a new one tried. Or it must be "debugged" so that it *will* teach. Or it must be *revised*—the material must be re-sequenced or something else must be done to the program until it finally teaches—until it is such an excellent program that it teaches *practically* everybody. Some idealistic die-hards are willing to say *everybody*. But *practically* everybody means 95 to 98% of your target population.

New vistas open up to the zealot of programmed instruction. Students that other teachers and schools have given up on now become ripe material capable of cultivation.

Programmed instruction is, in essence, a commitment—a commitment on the part of those who consider themselves teachers, instructors and trainers—to produce materials that will insure learning in as many persons as is humanly possible. It is the kind of commitment made to learning that is made by any true professional to his mission accomplishment, regardless of what specific nature that mission may be. It is a final commitment to quality.

Programmed instruction and automated teaching, rather than dehumanizing man, will humanize him. It is poor teaching, and poor, dull, and boring instructors who have hidden behind routine and drill, that have led to much student failure and to the subsequent dehumanization of man. Programmed instruction offers learning in the best socratic and tutorial tradition of teaching, asking that we bring difficult, stupid, unmotivated, and gifted though neglected students—"tempest-tost" by other teachers—and telling those students that the burden of learning is no longer solely on their shoulders, but that it is now equally, if not more so, on the shoulders of those who would consider themselves true professionals in the field of education and in what may someday become the science of pedagogy.

II. Education

THE EMERGENCE OF INSTRUCTIONAL TECHNOLOGY

Gabriel D. Ofiesh, Colonel, USAF

Colonel Gabriel D. Ofiesh, in the first presidential address to the society, points out that programmed learning is the first true system of instructional technology that assumes the major responsibility of learning, instead of placing it solely on the shoulders of the student. This educational technology, in common with other technologies in other fields, not only hypothesizes learning experiences for students, but further provides for the constant testing and revision of the hypotheses to insure that students do in fact learn. It is the hypothesis, testing, and revision procedure which is so crucial in the development of programmed materials that makes possible the transition from the arts of pedagogy to the sciences of instruction. It is in this that Colonel Ofiesh perceives the emergence of instructional technology.

Programmed instruction has emerged as the first valid system of educational and instructional technology that our society has ever had. It is patently in error to categorize programmed instruction, as has so often been done, as simply another medium or technique or among the various audio-visual devices. It is more than this. Oron P. South (1962) Educational Advisor at the USAF Air University, has pointed out that:

> Continuous change introduces new dimensions into the problem of education and training. Whereas in the past we learned from stable systems, now we have to learn from rapidly and continuously changing systems. Old ways of learning and old patterns for learning may no longer be appropriate.
>
> When change comes slowly and almost imperceptibly, one can be clear as to both the process and content of education and training, as these are worked out over a long period of time. The relevance of what is taught, to whom, and how, is matched against reality. What is dysfunctional is dropped.

As an innovation in educational technology, programmed instruction, like no other approach that we have had in the field of education, is dropping essentially "what is dysfunctional" in the learning situation and developing what is truly functional.

Many of the questions that are raised today regarding programmed instruction have been raised in the past in many other contexts. We have frequently heard the comment that programmed instruction is not new, that we have had it for years. It is probably valid to say that many of the characteristics of programmed instruction, independently considered, are not, in and of themselves, new. Programmed instruction, however, has emphasized these characteristics with a lucidity and force that no other instructional technique has to-date. Programmed instruction has in essence "forced the issue" on many of these questions. Prior to programmed instruction many of these questions were largely academic.

We should hesitate to say at this time that we have found, through programmed instruction, all the answers to the ultimate development of an instructional technology worthy of the name. Possibly through programmed instruction as a vehicle we can see the first signs of a true emergence of instructional technology. It may be that we are so desperate for a technology that our anxiety is causing us to over-project the significance of these signs.

Why is it that programmed instruction offers itself as such a vehicle? Why is it that programmed instruction is raising the issue of instructional technology as nothing else has done to-date? If instruction is to truly gain substantive professional status in the years to come, then it will in all likelihood do so as it develops an instructional technology worthy of the name.

If we ever develop a valid instructional technology, the teacher will gain prestige, because he will be able to actually structure productive learning experiences for students. Learning results will be so significantly superior that they will be convincing to all.

Such an instructional technology will allow instructors to be measured by the degree to which the student learns (not the degree to which the teacher "teaches"). There will be a realistic distinction made between those who "know the subject" (the scholars) and those who are able to take what the "scholars" know and put it into forms which are understandable to the student. We are not saying that those who do not know will teach. Nor are we saying that those who do know are necessarily effective teachers. The issue is too complex to be resolved by a simple statement or maxim.

Technology has been described as an application of science to art. In essence, an instructional technology will seek to apply what we know of the science of learning, along with what we may find out tomorrow about the science of instruction, to the art of teaching.

When we hear criticism that the present system of teacher education is inadequate, or that teachers are being assigned to fields for which they are not thoroughly prepared, we might ask what is really meant by "preparation". Usually this criticism means that a teacher is ill-prepared in knowledge of the subject matter that is to be learned. Preparation involves not only knowing the subject matter, but also knowing how to structure for the student experiences out of which, it is hypothesized, learning will emerge and knowledges and skills will accrue.

When a hypothesis is generated, the next step is to test it. The teacher is essentially a generator of hypotheses. It is the failure to test the many teacher-generated pedogogical hypotheses that has kept instruction a nebulous art rather than permitting it to develop as a science. We have been content to simply make educated guesses about the things we do as teachers. If the teacher were to test his hypothesis and find it wanting, then his only alternative would be to modify it and try it again, and again and again—ad infinitum. It is basically wrong, very wrong, to assume that the process of osmosis will transmit knowledge from the mind of the teacher to the mind of the student.

There is a need for a great deal of experimentation in developing instructional technology. Such technology, if ever developed, must of course be subject to verification as to its adequacy. There is a common impression among many teachers that the most significant part of their teacher training was the practice teaching experience, rather than the professional courses in education. This may or may not be a valid point. What is it about the practice teaching experience that gives this impression? To what extent does practice teaching provide the most effective training for the would-be teacher? Why do the usual courses in professional education give the impression, valid or not, that they do not have enough substance to train teachers in the skills of pedagogy?

Would-be teachers are urged on the one hand to increase their knowledge in specific subject areas and at the same time to strengthen their backgrounds in general education so that they may be able to see the parallel developments in other subject matter fields which relate to their own particular specialized interests. We cannot determine to any extent how any particular process, or procedure, or course will improve teaching ability until we are able to define in more precise terms than we have to-date the specific skills of pedagogy and how they can be validated. We must be willing to measure teaching ability, not by what the teacher does, but by what happens to the student and how he ultimately performs. It is the student for whom we must structure the experiences out of which, it is hypothesized, he will learn. It is, therefore, the student's performance that we must observe both prior to and following the learning experience. It is in observing this performance that we will determine how successful the teacher has been.

There have been, among other things, for example, indictments of institutions of higher learning for using graduate students to teach elementary freshmen courses. This indictment may be well taken. One questions, however, whether it is deserving when very often a graduate student may have technical knowledge of pedagogy which his scholar-professor-advisor may not have. One should not question whether a graduate student should teach a freshman his elementary course in a particular subject matter. One *should* question whether either the graduate student or the scholar-professor deserves to teach the course because of his lack of ability to communicate to the student what it is that he wants to teach. One questions whether the graduate student who aspires to become a scholar, and would like to spend most of his time doing research and writing papers which are deserving of publication, would have less interest or inclination to empathize with the student than would the scholar. Both professor and graduate student should be evaluated by their ability to teach students—in essence, to modify behavior in a substantive manner. This, above all.

We do not lack methods, ideas, procedures, or content subject-matter knowledge. What we really lack is something substantive in the training of would-be teachers which will validate those skills which are successful in modifying in specified predetermined directions the behavior of students. We need both quantitative and qualitative measures of what happens to the student and how he performs.

An instructional technology of any significance would be able to assess the difference between a successful learning experience and a relatively unsuccessful one. It would do even more than this. It would delineate several possible explanations as to why the one experience was successful and the other one unsuccessful. The instructor must accept the commitment and accountability for the results of the learning experience. The instructor becomes the person who will organize the system of instruction and may himself not even be a part of it any more than the director of a play may feel the necessity to play any of the roles customarily delegated to the actors.

An instructional technology worthy of its name will assist instructors in analyzing the structured learning experiences which fail to teach students. Determine

(1962) provides us with some insight to the possible reasons why many instructors find this difficult to do:

> In many cases even an experienced and skillful instructor will not be able to identify those subtle causes of a breakdown in instructional communication. An instructor might be evaluated by his students as being unable to communicate with them at their level, and it is likely that this criticism refers to the fact that most instructors, whether they are aware of it or not, make use of technical expressions, technical words, complex grammatical structures, and ambiguous or too-terse statements at a level of complexity that is not appropriate for the students. Obviously, an instructor does not have to operate at a too-technical level at all times in order to be guilty of this fault, since contact with the students can be lost in only a few sentences and never regained. It is often very dull to an instructor to elaborate on a point that seems very obvious to him. One difficulty is that the instructor is often unaware of the cause of the breakdown of communication and the basis for confusion. What is worse, from the point of view of instructional effectiveness in the future, is that very, very few instructors make any systematic attempt to analyze what happens in their classes. When an instructor loses contact with his students, continues to lecture, discovers that he must back up and cover some objective a second or third time, and then finally does succeed in clarifying the presentation, establishing contact once again, he is naturally not much inclined to stop at that point, make notes on the characteristics of his presentation that failed and those that were successful, but is, rather, at least as anxious as the students to move on to fresh, new topics. Most instructors who are proficient in the subject matter—which is to say that they have the relevant objectives in their own repertoires—often are ineffectual in their instructional presentations because they do not know the material from the point of view of effective sequencing for instructional purposes, and/or are unable to be consistent in presenting the material at a technical level that is understandable, and in doing so in small enough steps with adequate repetition, examples, clarifying analogies familiar to the student, and so on.

In looking at this problem many tangential issues have been raised. The question is not class size, teacher-student ratio, or the number of M.A.'s and Ph.D.'s on the faculty. The question is not the number of publications produced by the faculty. The question is not whether the scholars know very much about their subject matter. The question is not so much whether the student is willing and bright and motivated enough to learn. The question is not whether he has been properly selected. The real question is, out of the learning experiences which we build for the student, what really happens? How has his behavior changed? What is his nature before he came to us and what is it after he leaves us as teachers? What is the real value of the learning situation created by the teacher for the student? What does it produce in the way of knowledge, skills, and attitudes? What knowledge, skills, and attitudes does the student now possess that he did not have before he entered the teacher's zone of experience? Until we evaluate our teaching effectiveness by the product instead of the process, by what happens to our students and how they perform rather than by secondary criteria, we will never get to the root of the problem. Teachers who know how to teach and do not know what to teach are as common as teachers who know what to teach but who do not know how to teach it. I would like to entertain the notion that both of these examples are equally deficient. A scholar who cannot communicate his wisdom is just as inadequate as a pedagogue who has no wisdom to communicate. There are professors in our liberal arts colleges today who could do well to visit some public school, and find out what are the requirements of good teaching, as there are teachers and professors of education who could do well to visit the halls of liberal arts colleges and find in their staid text books what there is that should be taught. But in either case, the professor in his liberal arts ivory tower and the professor of education in his conventional, lock-step classroom, should both be willing to stand a test of saying, "Measure my effectiveness as a professor, as a teacher, by what happens to my students—not by what I say, not by what I do, not by how I behave, not by how popular I may be, not by my scholarly interests and achievements, but by my students. I submit that you measure my effectiveness by what happens to my students, and let my students speak for me and my skills by how they behave and perform, and nothing else."

Joseph Tucker has pointed out that if we cannot give deserving teachers merit pay because we cannot objectively differentiate between a good teacher and a poor teacher, then one might well ask how we distinguish between a teacher and a nonteacher?

There is no real quarrel with conventional instructional methodology. Note that we have said "methodology", not "technology." Rather, until the recent developments which have evolved with programmed instruction, there has never been an instructional technology, as such, to speak. Even today, one cannot say with any finality whatsoever that we have in programmed instruction a true instructional technology. It is merely that, through programmed instruction, one can see the first signs of only the probable emergence of instructional technology. It would be less than candid were we to state the issue otherwise.

If we consider programmed instruction within the parameters of all the foregoing remarks, then it is evident that programmed instruction is, at best, a system of instructional technology which forces the issue on many of the questions which have been raised. This is not to say that programmed instruction will provide the answers to all the questions that need to be answered; nor is it to say that programmed instruction is in and of itself the instructional technology that our society needs. It is to say, however, that the adherents of programmed instruction have concerned themselves with testing the experiences which they hypothesize will lead to successful learning. Programmed instruction has raised questions regarding the adequacy of present measures of learning experiences. Through programmed instruction we are questioning the value of present achievement measures and the extent to which they help us determine the effectiveness of the learning experiences. Programmed instruction has deepened the concern with retention of learning and with the sequencing of instructional content to mention only a few issues.

There has been an understandable concern with the procedures and techniques of programmed instruction itself and the devices of the accompanying teaching machines. If we concentrate, however, on the specific features of this innovation in its present very primitive and crude form and do not focus our perspective on the underlying concepts of programmed instruction, then we are not likely to find in programmed instruction the solutions to our problems of developing an adequate instructional and educational technology. What is more important to us, at present, is the underlying concept of programmed instruction as an instructional technology rather than the excessive deliberations about linear versus intrinsic programming, overt versus covert responses, teaching machines versus non-teaching machines, etc. Programmed instruction is a concept, not a set of techniques.

Through programmed instruction and teaching machine technology we have found a vehicle which permits us to study the educational process and to isolate the significant variables which will lead to further study. Programmed instruction and the accompanying teaching machine technology will provide a heuristic model for the development of instructional technology. Stolurow (1962a) points to this possibility in mentioning the advantage that teaching machines have over conventional instruction for experimental and demonstration purposes:

> One of the advantages which the teaching machine has over conventional instruction is that it freezes the instructional process during a study in a way which permits it to be used with many individual students. Furthermore, it isolates the instructional material and its plan of organization from the personality and related factors which heretofore have always appeared in an inseparable combination with the teaching method. The combination now can be studied as separate components to determine the relative effectiveness of the method independent of these other factors. Later, research studies can combine programming and presentation methods with the other factors, such as teacher personality, to determine how they interact with one another. Thus we see the possibility of making genuine progress, and, in fact, of using a truly scientific approach to study instruction. Through such an approach one should be able to develop a theory of teaching which could guide the classroom teacher, as well as the writer, in developing educational materials along more effective lines.

Through programmed instruction we are starting to think about the application of the engineering approach to the field of education. This is not to mechanize education, but rather to develop educational technology to the point where we can shoot with a bullet instead of a shotgun. Programmed instruction has forced us to concern ourselves with determining what it is we are about and establishing quality control for the process of education.

Through programmed instruction we have been developing a core of adherents who have committed themselves to students learning. Try-out students for programmed materials are sought in the circles of rehabilitiation, delinquency, drop-outs, and in penal institutions. Adherents of programmed instruction have said to school administrators, "Give us your failures. Let us try-out our programs on the students who have failed to learn." This has been a refreshing change on the part of a group of persons involved in pedagogy. This attitude, this type of commitment in education, will, more than anything else spur the development of instructional technology.

In summary, we can say that through programmed instruction we have started to put under very intense and comprehensive scrutiny the complete process of instruction and learning. We are asking questions about the relevance of our educational objectives and learning outcomes, the relevance of various media, and the compatability of conventional educational literature, to mention only a few.

It is difficult to anticipate the form that the technology of programmed instruction will assume in the years to come. We are at present in the first primitive and crude stages. Incipient in this concept, however, is the potential of an instructional technology that is beginning to emerge.

Someone has said that the greatest problem in communication is the illusion that it has been achieved. Programmed instruction has begun to dispell this illusion; instructional technology eventually will dispell it once and for-all.

PROGRAMMED INSTRUCTION AND THE PHILOSOPHY OF EDUCATION

John W. Blyth

Programmed instruction increases our ability to control behavior. In order to make this ability compatible with an acceptable philosophy of education we must determine who is to control behavior and for what purpose. John Blyth points out that one must not lose sight of the fact that in addition to intrinsic behavior, a philosophy of education must of necessity include the intrinsic behavior necessary to learn how to respond to the stimuli found in the world around us. Programmed instruction may be used to obtain the aims of a puppet philosophy of education based either on intrinsic or extrinsic behavior depending on the aims of the programmer, which we hope are in the direction of maintaining a free society.

OBJECTIVES

The most ardent enthusiasts about programmed instruction are usually quite eager to employ traditional methods of communication in the form of published papers and talks to groups. The papers and talks, however, do not always show any transfer effect from what should have been learned in developing a program.

All program writers have found it necessary to formulate the objectives of a specific program with considerable precision. To get the program started, it is essential to begin with something already familiar to the intended learners. The learning process then proceeds step by step toward the objective. In going through the program, the learner participates actively and is reinforced as he proceeds.

In this paper, I shall start by stating my objectives and shall then present some steps leading toward those objectives. But the steps will have to be fairly large, since much ground must be covered in a short time. Unfortunately, it will not be possible to elicit overt responses and offer positive reinforcement to all correct responses.

One further problem may be anticipated. There will probably be some people who will continue to emit the wrong responses, even after negative reinforcement. If the only reason for this is the strength of prior conditioning, then further remedial programs are called for to extinguish the wrong response and strengthen the correct responses. However, some programmers will undoubtedly claim that I am reinforcing the wrong responses and will offer counter evidence. This kind of disagreement is welcome, because it illustrates the fact that the question, "What is the correct response?" is not always equivalent to the empirical questions, "What response do people in fact make?" and "What response is reinforced?"

It is the fundamental objective of this paper to show that there are many important questions about education that are not equivalent to, and cannot be translated into and reduced to, empirical questions of fact, or questions about behavior. In more general terms, the philosophy of education is not identical with, and cannot be reduced to, the psychology of learning or the science of behavior. In scientific inquiry, it is essential to formulate our questions in a way that makes it possible to answer them by appeal to observable data. But it is equally important to recognize that there are many very important questions that are not answered by scientific inquiry.

Confusion on these matters works both ways. On the one hand, there are unwarranted claims that we now have a science of behavior which will provide scientific answers to all questions about education. On the other hand, there are many educators who are reluctant or unwilling to take advantage of the results of scientific inquiry because they believe mistakenly that this commits them to an unacceptable philosophy of education.

There are widespread, although poorly defined, fears that we are committed to a kind of puppet philosophy of education if we admit that there are ways to control human behavior. These fears are augmented by the fact that determinism is an integral part of communist doctrine and the fact that total control of human behavior is a deliberate aim of totalitarian governments of all kinds. It is believed that we must reject the view that behavior can be controlled in order to maintain a democratic and humanistic philosophy of education.

I hope to cut through some of the confusions arising from a failure to distinguish scientific questions from philosophic questions. Programmed instruction increases our ability to control behavior. This opens up opportunities for more complete regimentation of men in totalitarian states and for more complete realization of human values in democratic states. With better knowledge about how to control behavior, the important question is no longer whether behavior can be controlled. The important question is, "Who will control behavior and for what purposes?"

PHILOSOPHIC AND SCIENTIFIC QUESTIONS

The first step in a program usually starts with something familiar. One thing familiar to all programmers, and one of the few things on which they all agree, is the fact that the first step in writing programs is a clear formulation of the objective. It is frequently urged that the specification of objectives should be given as a description of the terminal behavior to be produced by the program.

By stating objectives in terms of observable behavior, it may appear that we are still concerned only with questions to be settled by scientific observation. But this is impossible. If we follow the recommended procedure of specifying objectives before writing a program, there is, at that time, no program and hence no terminal behavior to observe.

No one has seriously proposed a kind of actuarial programming technique in which one first writes a program and then administers the program to different groups to develop a table of terminal behaviors produced. Pushing the analogy one step further, we might use a sort of mortality table to identify a target population. That is, we identify the target population by finding what group of people produce the intended terminal behavior.

Programmers do not work this way, either in theory or in practice. They first specify objectives for the intended group of students. The program is then developed and finally tested on the intended population. Observations then become possible to determine whether the actual terminal behavior corresponds to the intended behavior.

In short, there is no scientific answer to questions such as, "What is the intended terminal behavior of the program one is about to develop?" There is, of course, a school of thought which would reply that this question is a meaningless question, because it has no scientific answer. From this point of view, an answer to the question would be equally meaningless, so we would be left with no guide in developing a program. We can only charge blindly ahead writing frames and then see what happens.

Questions concerning the objectives of a program are apparently meaningful for those who answer such questions before writing a program. They should be able to take the next step with me. Questions regarding the aims or objectives of an educational system are like those regarding a specific program. They are not questions of scientific fact. They are questions in the area of the philosophy of education. No matter how much scientific information we acquire about the control of human behavior, there are important nonscientific questions concerning who should exercise control and the purposes to be realized by that control.

The distinction I am making works both ways. Empirical scientific investigation of the factors influencing behavior does not answer philosophic questions about the aims of education. Nor does philosophic inquiry about the aims of education settle any questions of fact regarding the most efficient method of attaining those aims.

THE NATURE OF MAN

The steps leading to the discrimination of a philosophic question from a scientific question started with the acknowledged fact that programmers specify the objectives of a program before writing it. To take the next step, let us look at another aspect of the programmer's activity.

Does the program writer make a choice between possible alternative objectives? The answer to this question is ordinarily "yes." The answer is "no" only in cases where the program writer is acting under orders from an editor or an employer. But in those cases, there is always someone in a position of authority who has made the choice.

This apparent dilemma involves a deep-seated and persistent confusion. The confusion is generated by a failure to make a few fairly simple discriminations. One important discrimination is suggested by the case of the program writer who is acting under orders in selecting an area for programming. Since he is not making a free choice, it might properly be said that his actions are controlled or determined for him. If the action of the man under orders is said to be determined, it appears that we must say that the action of the man who makes a free choice is undetermined. Thus, accepting the view that human behavior is determined seems to preclude the possibility of free choice.

At this point, an apparent conflict emerges for a programmer who has made a choice, but also believes that human behavior is determined by antecedent causes. If his actions are all determined, he cannot understand how he can make a free choice.

The verbal behavior just described should receive negative reinforcement, since it constitutes the wrong response to questions about free choice. The following steps lead to the correct response.

In this age of rocketry and automation, some of the clearest illustrations come from new developments. Some rockets are launched to follow a predetermined course. Their trajectories are determined by the force and direction of the rocket thrust. The action of the rocket is entirely under external control.

Somewhat more complicated rockets have a built-in guidance system. The guidance system may be preset to follow a predetermined path, or it may be designed to locate a moving target and follow that target until overtaking it. In the former case, the behavior of the rocket is predetermined in its entirety. In the second case, the behavior of the rocket is, in part, under the control of an internal guidance system. Its course is determined, not by some completely predetermined sequence of signals, but by the responses of the guidance system to signals sent out by the rocket and bounced back from the target. There are also rockets with more complicated guidance systems. Their systems make them partially responsive to ground control signals and partially independent of such external control. The guidance system continuously processes signals from the ground and feedback from signals sent out by the system. The behavior of the rocket is thus determined by the output signals from its own guidance system.

For each type of rocket just described, let us ask whether there is any suggestion of action or behavior not determined by antecedent events. The answer is clearly "no" for each rocket. Next, let us ask for each rocket, whether any of the rocket's behavior is independent of external control. In this case, the answer varies from one rocket to the next. The rockets vary in the degree of control exercised by external events in relation to the degree of control exercised by internal events. Those rockets with an internal guidance system exhibit a certain amount of self-control. Thus in modern rocketry we find clear examples of a situation in which each action of a rocket is determined by antecedent events, but it is also correct to say that some of their actions are free from external control.

We have now discriminated two distinct questions which have been confused in the traditional controversy over determinism and free will. We can now resolve the apparent dilemma of the program writer who thought he had no freedom in choosing objectives, because he believed all his actions were determined. Let us separate the question as to whether his behavior is determined from the question as to what determines it.

Is the behavior of a human being making choices determined by antecedent events? The answer is "yes".

Is the behavior of a human being making choices determined by external or internal antecedent events? The answer to this question will be "yes" in some cases and "no" in others. We should also recognize varying degrees of internal and external influences. A human being is in constant interaction with many forces in his environment. Some of his actions are directly responsive to external stimuli. But most of his actions are determined to some degree by the processing of stimuli by his internal guidance system. To the extent that this is so, he is acting freely in making choices.

A philosophy of education is concerned with the aims of education. The formulation of these aims is necessarily affected by our view of the nature of man. The scientific study of human behavior presupposes that human actions are determined by antecedent events. This hypothesis not only does not conflict with the formulation of a philosophy of education, it is indeed presupposed in such a formulation. Teachers always have and always will assume that their actions have some influence on their students. The notion of a disembodied free will which somehow causes uncaused actions has never been a useful concept.

The view that man's behavior is determined is an important premise to work with, but it does not settle any of the important questions in a philosophy of education. Among other things, a philosophy of education will specify the aims of an educational system for individuals who are to learn certain ways of behavior, and are to learn certain subjects. The individual being educated makes many responses to stimuli, but the individual is not a mere aggregate of separate stimulus—response connections. It is not responses that go to school, but the individuals who make responses. The philosophy of education requires a more satisfactory concept of an individual than we obtain simply by studying stimulus—response—reinforcement patterns. Of course, the science of behavior also requires some such concept.

The study of astronomy is quite different from the study of the behavior of astronomers. The satellite Mariner was not sent around the world to examine the behavior of astronomers. It was sent up to examine the behavior of Venus. Our knowledge of astronomy is certainly created by the efforts of astronomers. But the subject of astronomy cannot be reduced to the astronomer's behavior any more than a piece of beefsteak can be reduced to the act of chewing. In short, the philosophy of education must go beyond the science of behavior in formulating a concept of the subject to be taught to individuals.

And, finally, the philosophy of education is concerned with the aims of education. As indicated above, questions regarding aims and objectives are not scientific questions. A consideration of aims takes us back to the individuals whose aims are involved and forward to groups of individuals in society.

A PHILOSOPHY OF EDUCATION FOR A FREE SOCIETY

We are now nearing our objective of clarifying the relation between programmed instruction and the philosophy of education. We have taken the following steps:

1. We have distinguished questions concerning the objectives of a program and of an educational system from questions concerning the most effective way to attain those objectives.

2. Questions about the aims of education are philosophical. Questions concerning the most effective way to attain those aims are scientific.

3. We have discriminated the question as to whether human behavior is determined from the question as to the location of controlling factors.

4. We have seen that the view that man's behavior is determined is not incompatible with the making of choices or, incidentally, with a conception of individual moral responsibility.

5. And, finally, we have seen that the philosophy of education requires several concepts going beyond the science of behavior.

The significance of programmed instruction and all other technological developments for a philosophy of education lies in the increased control over the educational process which is now possible. However, increased control over human behavior is like increased control over atomic energy. The mere power to control is morally neutral. Both kinds of control can be exercised for quite different objectives.

In authoritarian societies, the goal of an educational system is to bring the control of individual behavior more and more under the direction of some central authority. In such a society, the locus of controlling events is external to most individuals. This is a puppet philosophy of education. The authorities pull the strings. The individuals are like the rockets with a guidance system responsive only to external control signals.

In a democratic society, the goal of the educational system should bring the control of an individual's behavior more and more under a developing internal guidance system. The goal, of course, is not completely independent from external signals. The person who becomes entirely unresponsive to external stimuli requires institutional treatment. The goal of a democratic free society is to maximize the areas of individual choice. The successful operation of such a society requires citizens educated to make decisions for themselves, both individually and cooperatively. They must have a guidance system which is not unresponsive to external stimuli. But their overt responses to external control signals will be mediated through their internal guidance system.

In short, in a democratic society of free individuals we need more, not less, knowledge about the control of human behavior. In particular, we need much more knowledge about how to improve the internal control systems of individuals. This suggests the direction in which further scientific inquiry is required. This will be a more difficult stage of inquiry because at least some of the determining events are not so readily discriminated and observed as overt behavior.

Programmed instruction may be used to attain the aims of a puppet philosophy of education, emphasizing external control, or to attain the aims of individualistic philosophies of education, emphasizing internal control. Let us hope that we can program the applications of programmed instruction to maintain a free society.

PROGRAMMED INSTRUCTION AND THE CONTROL OF BEHAVIOR

William A. Deterline

William Deterline points out that versatile free minds as a goal of our education system can only be achieved through a highly disciplined and controlled learning environment. He insists that the lack of control is more likely to produce undisciplined slipshod thinkers than creative unstifled individuals. He believes the American educational system needs the greater discipline that programmed instruction can provide to produce men educated to their fullest capacity.

I do not intend this paper to be a polemic aimed at education. The government commissions officers who are admirably qualified for that purpose. I do not even feel that my remarks are unjust criticisms of all educational practices, even though I am about to make some disparaging remarks about many of the products of American education. First I intend to alienate almost all educators by criticizing the fruits of their efforts. Then I intend to alienate almost all advocates of programmed instruction, because I believe that programs, as we write them now, do not do the things we ascribe to them. Our programs are little related to our laboratory techniques of shaping behavior, or to our favorite old saw, the tutor-student interaction. In spite of this approach I hope that the tone of this paper will not be a completely negative one. I do believe in the potentialities of programmed instruction, and I will take exception to the cautious and conservative statement that programmed instruction is not a panacea for the problems of mass education and training. I firmly believe that in our present crude art lie the seeds of just such a panacea.

"Control of Behavior" is a phrase that seems almost to be in direct antithesis of our idealized educational objectives of developing "free minds" and of providing a liberal or liberating education. There is little doubt in my mind, however, that we achieve that educational objective only when our instructional methodology exercises an extremely tight degree of control over the behavior of the learning organizm. This apparent contradiction in terms, production of a versatile, freely adaptive thinker through extremely tight and rigorous control of his thinking during learning, is actually not a contradiction at all, but a blurring of the distinction between means and ends. One is the end and the other is the means. Because we have never in the past completely exercised these means, we have very rarely achieved the desired end.

Generally speaking, the product of our formal educational institutions, through college, is not a liberally educated student but a sparsely educated one. Instead of turning out "free minds", we produce unliberated, undisciplined slipshod thinkers whose primary educational distinction is the impressive way that they have slipped through 12 to 16 years of instruction without thoroughly mastering any subject. Certainly we want creativity and adaptability, and many classroom teaching techniques give the student freedom to attempt creativity and free expression. But all too often these activities are unguided, uncontrolled, and, as a result, actually interfere with the desired learning. Our high school and college graduates tend to have an impressive capability for impractical, unrealistic, ineffective and uninformed guess work that is, in part, the product of a lack of disciplined basic intellectual skills.

We admire the educated guess and deplore the blind stab, yet we do not consistently produce educated students who are capable of educated guesses. Why not? Too often during a student's academic career, he never learns the things to which he is exposed; his response repertoire is not permanently changed in the desired direction.

We are proud of our educational system, and, up to a point, we should be. We do have effective mass production of sparsely educated people despite the shortage of good, dedicated teachers. Something is wrong, however, and the examples that should bother us are quite plentiful. During the late 1930's and early 1940's the United States built the atomic bomb, and we used physicists and chemists and engineers from many other countries to do it. Look at the great names that were involved in the Manhatten Project; names of men at the very top of their fields from all over the world. Only a few of the very great were products of American education. I read recently that Leonard Bernstein is the only native-born conductor of a major symphony orchestra in the United States. I don't know whether this is true, but even a much larger proportion would still be appaling. There are many more examples like these that indicate that, per capita, American education is not turning out enough top flight scholars. These examples are not cited in order to compare U.S. education with education in other countries, but only to point out the apparent waste of raw material in this country.

What do we accomplish in our schools? We do develop a great deal of social conformity, but we do not, unfortunately, develop enough academic conformity in subject matter areas. All of our high school graduates may be able to tell us that the sum of 2 and 2 is 4, but beyond this level, conformity in demonstrable knowledge and performance is extremely limited. We should strive for conformity in certain basic methods, facts, relationships, and necessary broad objectives of instruction. We should produce a more uniform product at every grade level, and we cannot blame all the variance on innate individual differences. Industry and the military services spend many millions of dollars every year in what amounts to remedial training of high school and college graduates. These students missed too many fundamentals that should have been acquired by all students. Granted, our classrooms are crowded, good teachers are in short supply, and the curricula are often crowded with non-essentials, but our greatest deficiency, I feel, is the extreme lack of uniformity of proficiencies of our students at all levels. And this leads directly to my original topic, the control of behavior.

As an organism responds, he learns. Learning is inefficient when the learner is given no steady support, no continuous guidance, and no continuous stimulus inputs that require specific response outputs. We lecture to students but fail to try to control their thinking about the subject matter so that only accurate thought patterns occur. In effect, we turn the students loose and hope that they will think the way we do. We want the thinking of the students to emulate the thinking of the teacher, but rarely do we show them how we think; and rarely is the desired behavior shaped in the students with any kind of uniformity. Instruction is still too much an osmotic process in which the learner is the sorter. He must organize and select stimuli, and produce responses without adequate guidance. The student's success as sorter and structurer of knowledge is never very certain, because we force him to play the game of trial and error. When conventional instruction is criticized because of its lock-step pacing, its failure to insure continuous active student responding, its complete lack of immediate reinforcement, and so on, I think we are only identifying facets of the much larger deficiency, lack of control of learning.

Programmed instruction provides a measure of control of behavior beyond that currently a part of any conventional instructional methodology. Programs may never reduce the number of teachers in our schools (although programmed texts may replace most of our unprogrammed textbooks), but programs will certainly provide a degree of controlled behavior that will replace much of the uncontrolled behavior that currently fills the student's time. By this it is meant that a program will unerringly guide a student from the beginning of the study of a topic directly to the objective of that topic without losing control of the student's behavior. We say that students must be actively involved as they use a program, but this is not that big an innovation. Some students are passive some of the time, of course, but that passivity is far less detrimental than the inappropriate active responses that carry the student into unrelated topics or into incorrect conclusions and extrapolations.

Uncontrolled active responding is far too common in many of our classrooms. Active responding by itself is not necessarily desirable, unless optimum control is exerted over the stimulus environment and over the direction and content of the behavior sequences. We can make use of programs to control student behavior by keeping learning guided in a direction that reliably produces the desired finished product. The bad work "uniformity" may rear its ugly head, but we *do* want to produce certain uniformities of knowledge. The creative individuality of a college student who spells Pennsylvania "P-e-n-s-i-l-vania" or who demonstrates complete lack of comprehensible conformity in expressing himself in writing, or in solving a simple problem in mathematics, is not a desirable activity. It is also not very individually creative for a college student to define "indivisible" as "something we cannot see." I have seen each of these examples of non-uniformity, but I don't think that this is the kind of creativity we seek.

A student can be creative and original only if he is prepared for it. Instead, we allow creativity as a teaching method to interfere with and even preclude the possibility that the student will ever achieve a solid background preparation for creative judgement.

It was Newton, not Mac the cobbler, who built us a physics. The contributors to science, technology, the arts and humanities have not been the partially trained: they have been individuals thoroughly grounded in both basic principles and the more abstract forms in their knowledge areas. Integration of new knowledge is relatively easy for one who is thoroughly prepared, but extremely difficult for the dabbler. We now principally turn out dabblers who know very little. Our colleges are probably even more guilty of this then are the public schools.

College students encounter some very rudimentary statistical concepts in general or educational psychology, and panic generally ensues. These students were only dabblers in their mathematics courses and their behavior was probably so extremely uncontrolled through elementary and secondary school that they never became reliably competent in mathematics. Vast numbers of college students wail plaintively, "I'm having trouble with this statistics chapter because I have a mental block about mathematics", and we must admit that both competing emotional responses and competing intellectual responses do occur. These blocks stand in the way of successful learning of the statistical concepts, formulae and operations. Unfortunately, students who make the claim of mathematics mental blocks do so almost smugly because our society condones a satisfaction with academic incompetence in the difficult areas of math and science.

Students who are not competent at lower level skills or fundamental stages of understanding are severly handicapped when higher levels are assigned. Students who proceed through a good program are competent at each step in the program and this competency will contribute to the elimination and prevention of mental blocks. Trial and error and learning to avoid previous mistakes, Norman Crowder notwithstanding, are not the most effective and efficient learning processes.

My emphasis on greater control of the learning process is subject to the same criticisms that have been leveled at programmed instruction for other reasons. L. J. Cronbach, one of our leading educational psychologists, has criticized programmed instruction severely, feeling that our current instructional methods are good enough, having stood the test of time. Other educators have echoed these sentiments. But time is a poor test. Aristotle's assertion that heavy objects fall faster than lighter objects stood the test of time for 2000 years until Galileo tested it. Old theories of matter satisfactorily stood the test until 1900 when they became inadequate and had to be drastically revised in order to allow science to enter the nuclear age. Uncontrolled instructional technologies must make room for a technology that will add a greater degree of control to the learning process in order to allow the system to become more effective. Teachers have always felt twinges of futility when correcting examination papers, because so many students demonstrate so many deficiencies by their inability to answer questions. Greater control through programmed instruction may not be the whole answer, but programmed instruction can certainly provide a tremendous contribution by controlling learning, thus helping to produce graduates with a more thorough and less variable repertoire of proficiencies.

There is only one thing wrong with this picture, and that is the problem of validity of our existing analysis of how and what programmed instruction should do. We say that programmed instruction came from the psychological animal laboratory. We also draw the analogy of programmed instruction with the Socratic or tutorial interaction. These extrapolations are elegant and enlightening, but they may be false, and this is an alarming possiblity.

In teaching motor skills it is easy to control the student's behavior because we can see what he is doing or is about to do. We can guide his behavior, evaluate it continuously, and stop any missteps before they have more than begun. Intellectual learning is not visible; we can never really know what kind of covert responses are occurring unless they have an overt counterpart. One result of this difference is that we can produce a skier or a swimmer or a sculptor faster than we can teach intellectual skills. We can guide and control motor activity, but thinking is not visible enough to tell us how to guide or what controls to apply. Thinking continues even while a student reads a frame and responds to it. So far we have not been able to get this behavior completely under control. Sometimes this thinking helps the student move forward, but just as often it may lead to errors, misconceptions, negative transfer, and so on. Our animal analogies from the laboratory are based on motor skills and may have very little to do with human conceptual learning!

I intentionally overstate the degree of my concern with the possibility that the behavior we call thinking may not be adequately controlled or controllable by a program. I assume that thinking behavior follows the same principles and obeys the same laws as other aspects of behavior. The success of our programs has given support to this view. If this assumption is correct, it means that we can eliminate the most undesirable aspect of human learning in our schools: the unguided, uncontrolled trial and error activity that the student emits in response to the presentation of material that is to be learned.

The student faced with the problem of adding to his repertoire those responses that will adequately handle problem situations in the classroom, on tests and in application outside the classroom, needs all the guidance and control that we can provide. When his behavior is not guided and controlled, much of his activity goes unreinforced or is followed by aversive consequences. As we would expect, the result is extinction or avoidance learning. Students do not learn the subject matter, and what is worse, develop a "mental block" for that subject or for academic learning in general. Mastery and competence, as we use these terms, provide the basis for continual reinforcement of successful performance. My main point is this: losing control of the student's behavior as he learns means that we cannot prevent undesirable learning; incorrect answers and emotional responses such as frustration and avoidance will occur. When we control his learning we insure, not only the acquisition of the desired responses, but also the prevention of undesirable behavior.

It should be clear that I am not advocating classroom control in the sense of stifling self-expression, reducing the adaptability and flexiblity of the teacher, or reducing the classroom interaction to a regimented, non-social and "no fun" experience. Only a small part of the student's time is spent in the acquisition of knowledge and skill, but this activity must be controlled as carefully as possible if instructional objectives are to be achieved. The advice given to beginning golfers and skiers, to employ a skilled instructor so that no bad habits can be learned, is the equivalent of advising the learner to obtain a competent source of control of the learning process.

There is an aura of smugness apparent in many articles and papers that reflects a general feeling that programmed instruction has arrived! There are certainly impressive experimental and applied results, but programmed instruction has not yet arrived at any comfortable and assured place in our instructional framework. I feel, as do many psychologists, that these very crude beginnings in the application of behavior theory to the practical needs of society need to be recognized as being crude.

In the past the classification of programs as either linear or branching reflected two different attitudes toward control of student behavior. Early branching programs, I feel, exerted too little control over the student; his thinking was too lightly controlled between the questions that separated the units of textual material. After learning had or had not occurred, the program reacted appropriately, letting the student proceed or correcting the error that the program had diagnosed. Early linear programs, on the other hand, insisted that all students must fit a single mold program, encountering exactly the same stimulus sequence and following exactly the same behavioral sequence. Neither of these approaches has been completely adequate. A branching program was able to adapt with some flexibility, but exercised too little control, while a linear program provided almost too much control since it could not in any way adapt to the developing capabilities of the students.

The use of various kinds of branching, bypass, washback and other types of adaptive sequencing has made basically linear programs into much more powerful instructional materials. Unfortunately, we too often lost sight of the very behavior that we were trying to shape, became enamored of a technique and, like our programs, remained rigid and inflexible.

Programs must include adaptive sequencing in order to maintain an adequately tight control over the studuet. If the interaction between a student and a program cannot bend, it will break. I think the worst offenders in failing to provide adaptive control have been the Skinnerian experimental psychologists, of whom I am one, who have transferred their attention from the systematic production of behavior in animal laboratories to the production of human behavior via programmed instruction. In the animal laboratory, electronic control gadgetry, called programmers, are used to provide all stimulus inputs to our experimental equipment and the subjects inside, and to provide all appropriate stimulus consequences of the subject's behavior. Even the electronic equipment has a great deal of adaptability built into it, manipulanda that react to a wide range of response intensities, topography, direction and so on. Latching relays and delay circuits are also used to provide for certain acceptable latitudes in response latencies and frequencies. Even so, some of our subjects will not adequately develop the response patterns wanted, so we often resort to disconnecting the programming devices and using the extremely adaptable method of successive approximations in order not to lose a subject. Unfortunately, in preparing programmed instructional materials we have not been equally adaptable.

Control must be maintained but should not be confused with an inflexibility of control that can often be as disruptive as too little control. We have already strayed too far away from the student and although we give lip service to his role in developing programs, we too often do not use him until after the basic sequence is written and all formats are established. We do not now allow the student to control the programmer as we should. What I mean is that we psychologists, academicians and training specialists have already turned our backs on a basic premise of programming—that the program must be written to interact effectively with students and that this can best be accomplished by having students participate actively in the programming process right from the beginning of work on the program.

Programming principles, as noted earlier, are based on laboratory procedures for producing motor behavior sequences in lower animals. There is an appallingly small amount of experimental data dealing with the analysis of these principles applied to human conceptual learning. Only a little research is being done that will eventually provide us with additional techniques which can adequately control the human learning processes. Only when tight, predictable, reliable control of learning becomes an available technological tool will psychology have made its contribution to education. Only then will education have some hope of becoming a scientific technology rather than an art that is practiced well by only a very, very few.

PROGRAMMING THE IMPOSSIBLE

David J. Klaus

David Klaus points out that in the early stages of any developing technology, attempted predictions often prove to be significant underestimates. He draws analogies and concludes that much which is now considered impossible in education will be achieved through programmed instruction.

One of the most disturbing aspects of programmed instruction is the amount of sensationalism surrounding it. The terrors of mechanical teachers offering mass-produced, push-button education is the starting point of most articles to be found in the daily press, in Sunday supplements, in popular magazines, or even in trade publications. Unfortunately, every headline suggesting robots in the classroom is followed a short time later by the statement of a responsible local educator that no dramatic change is contemplated and that parents may feel assured that their children will not be subjected to any such radical revision in instructional practices. Rarely does the public hear of the legitimate successes of competently conducted investigations. Instead, there is a tendency to publicize the guarded comments of educational conservatives who continue to regard the potential of programmed instruction with considerable skepticism.

Historically, even the most optimistic predictions concerning any developing technology often prove to be significant underestimates. What is impossible one day may well be commonplace the next. This is certainly no less likely to be characteristic of programmed instruction than of any other technology. For the researcher, the impossible becomes an objective, a challenge.

Because such goals as producing students who are able to judge fine art with sophistication, uniformly able to create original proofs to geometric theorems, solve problems in calculus before they are ten, or learn a language so thoroughly that all of them master all the vocabulary and grammer given, are not within the current capabilities of education and training institutions, does not mean these goals can never be achieved. The researcher must try not only to better understand how learning occurs and how it may be enhanced, but to use this knowledge in attaining desirable objectives as well. In a sense then, programming the impossible could never occur unless there was a universal willingness to accept the present status of education as one which defied improvement. Because a legitimate goal has not been attained before does not mean it is forever beyond reach. Only so long as there are deficiencies in education will there be room for new techniques and only so long as there are those willing to say some one goal is inherently unattainable will it be possible to program the impossible.

In another sense, programming the impossible can never be a reality; there always will be new problems to overcome. Yet, it is worthwhile to look at some past and present views of programming with the hope of stimulating program users, and possibly program producers, to seek new horizons and not dwell complacently among their existing, and unfortunately reinforcing, accomplishments. It must be remembered that in discussing programmed instruction, it is all too easy to over-generalize and suggest that more has been accomplished than the findings warrant. Those vast improvements which were often predicted for programming have not fully materialized, at least as yet, and are not likely to do so without considerably more research. Nevertheless, programming already has made significant progress, at least enough to cause concern to the traditionalists and offer hope to the revolutionists, and much more can be expected.

An important consideration of programming research is that the problems to overcome are typically the problems of education in general. Parents, teachers, and administrators, to say nothing of the vast majority of students, agree that every effort should be made to develop instructional resources that are capable of producing more efficient, effective, and economical learning. The dedicated educator is far from pleased unless all of his pupils learn as much as possible as rapidly as possible. He may well be skeptical of magical formulae and unwilling to adopt new techniques without thoroughly investigating their advantages and limitations. Such an educator does not perceive programming as threatening, nor is he anxious to defend the mediocrity he himself is capable of identifying in many current educational practices.

The first reaction to programming, now rarely heard, is that it simply cannot work. Students are too variable, too inattentive, and too much dependent upon skilled supervision to ever profit from printed materials, regardless of how they are presented. Programs, at least early programs, did not appear too terribly different from textbooks or workbooks used regularly in the schools. But students could and did learn from programs, a finding perhaps more significant than any other thus far obtained. The systematic control of learning by means of carefully prepared and sequenced learning experiences was shown to be not impossible;

it was shown that the materials and the outcomes they produced easily and conveniently could be replicated wherever and whenever desired. This is not to imply that programs, especialy the early ones, were not without shortcomings. These programs often had limited applicability and frequently had errors in content. They were frequently tedious to all students and fully successful for only a narrow range of them. But they worked. To many programmers, this remains the most important development of all. Unfortunately it is a result which is frequently overlooked by those anxious to focus attention on whatever programming has not yet been able to achieve.

That programmed instruction could successfully assume the burden of instruction where other media often fail was an impossibility only to those who have not kept pace with the rapid growth in knowledge of the learning process. Until recently, most texts dealing with educational psychology carefully distinguished between human learning and conditioning studies. Far greater emphasis was devoted to findings on serial-position effects and the meaningfulness of material than to reinforcement and stimulus discrimination. The function of the classroom teacher and textbook writer alike was to inform, demonstrate, explain, and sometimes discipline; but it was the student who had to study, learn, and remember. Successes were credited to the capable and energetic teacher; failures to the dull and inattentive student. Programmed instruction was capable of producing a degree of control over learning that was beyond the scope of any other form of instruction concerned primarily with the presentation of information. Regardless of whether they taught better or faster than more traditional forms of instruction, the fact that programs did teach and could assume the burden of instruction remains an impressive and still important finding.

The second impossible objective sought by many programmers was the development of a technology which was capable, on empirical grounds, of surpassing achievement standards that are generally regarded as satisfactory in the schools. The suggestion that properly prepared materials could be expected to lead to ninety per cent of the students learning ninety per cent of the content was made during an orientation course for military training personnel in response to a class member's question. While it was tempting to reply that a goal of everyone learning everything seemed reasonable, it also seemed reasonable to make some allowances for inadequacies in the state-of-the-arts. At that time, only a small fraction of prepared programs were this satisfactory, and more than one member of the class felt free to demonstrate his belief that this goal was impossible. Yet, by subsequently insisting upon that level of quality in its own extensive programming effort, the Air Force has shown this to be a realistic goal; one which undoubtedly could be attained by programs developed for other educational use as well.

Uniformly high standards of achievements are almost an inherent property of programmed materials. Given enough patience, the program writer could subject his sequences to as many cycles of tryout and revision as are required to produce any desired attainment. Certainly, the systematic use of empirical data to improve a unit of instruction is not exclusive with programming. Yet, it is difficult to explain why such an objective as ninety per cent of the students learning ninety per cent of the content was thought of as impossible. Perhaps it was the recklessness of enthusiastic zealots, as some programmers are described, or perhaps it was the confidence of educators and training specialists that the standards established could not easily be achieved which led to this goal. Whatever the reason, however, the uniformity of high standards of achievement which can be produced by programs undoubtedly will have a lasting impact on many facets of education and employment.

A third impossibility which is being overcome concerns programmed materials which are capable of dealing with the wide heterogeneous range of individual talents found in a typical classroom or with the peculiarities of special groups. For years, the individual has been an outstanding concern in education; yet, except for the limited adjustments made possible by multiple tract systems and special classes, it was not possible to provide the individual attention so strongly recommended. Similarly, it was thought to be impossible for programs which have uniform content and which are administered with no provision for student questions to provide for the peculiarities which make students different. In making this assumption the ease with which programs adjust to variations in learning ability and student background by means of individual pacing through branching, by-passing, and similar techniques was largely ignored. The seemingly overwhelming problem associated with students completing a course of instruction at different times was not seen in proper perspective; no one asked why it is important for all students to finish together even if they are not equivalent in achievement. It should be apparent that anyone clever enough to cope with graduates having achieved a random mastery of the subject in constant time can successfully deal with graduates all having similar achievement but learned in varying amounts of time.

One paradox of programmed instruction which reflects this impossibility is the pride with which many teachers point to the use of programs in dealing with students needing remedial instruction. How strange it is to hear of the success of a program when applied to the most difficult cases from educators who are reluctant even to try the same program for the regular instruction of the remaining students. A second paradox concerns the concept that students will be molded to an unnecessary degree by programs. If this concept is used to raise an objection to giving the dullest in a group the opportunity to be alike in knowledge learned to the very brightest students, then much will be gained by having greater uniformity in instruction. On the other hand, if the objection is meant to imply that it is impossible for each student to learn something different, it should be evident that programmed instruction will make it feasible to offer all students a choice of languages, sciences, and other subjects to an extent not possible in most schools today. Required courses were inserted in the curriculums, hopefully not to facilitate checking attendance, but rather to produce students who were uniformly successful in learning uniform content.

Other individualized aspects of learning, such as motivation, are certainly problems. While it has not been impossible to make programs interesting as well as instructionally effective, this is an area in which much more progress can be expected. One significant aspect of the approach being used by most programmers is that learning need not be difficult to be good. Why learning should be considered an effort, and described as schoolwork or homework, has never been made clear. Certainly, entertainment is not the objective of education; yet, instruction must compete with other opportunities offered to the student and should be at least not unrewarding or unpleasant. It should not be impossible to devise programmed materials which will incorporate new techniques or material necessary to attract learners. Perhaps, someday, research will reverse the present situation and the circus performer, television producer, and fishing supply salesman will look enviously at the educator, and apologize for his own poor showing by expounding knowledgeably on the problems of motivation.

The fourth impossibility it that the rules of animal learning might be reasonably valid when applied to human performance, the principles of conditioning, regardless of which set might be employed, could be used to enhance human learning. It should be clear, however, that even if premises such as insight, reflection, rationality and other supposedly human qualities are granted (and many behavioral scientists are unwilling to grant such premises) it has been possible with programming to produce more efficient and effective learning than has previously been accomplished through mass media. Programmed instruction represents one of the first opportunities to systematically produce or engineer desired changes in human behavior. Perhaps this forebodes an uncomfortable societal problem since the control of skills and factual knowledge is not far different from the management of concepts, attitudes, and opinions; and since these are not much different from the manipulation of advertising or propaganda to produce lasting and profound changes in politics, commerce, ethics or fundamental beliefs.

The rules used in preparing programs are presently inconsistent, inaccurate, and far from inclusive. Yet enough is known to produce reasonably rapid kinds of change in generalized responses or what is generally interpreted as changes in attitude or judgment. Although attitudes, and similar forms of complex behavior, are not taught deliberately, they are certainly learned. It should not be too far in the future when programs will, in small deliberately planned increments, provide the opportunity to acquire a particular attitude toward some political party, economic institution, esoteric organization, or consumer product. Commentators, public relations specialists, and advertisers represent an expenditure of considerable time, effort and money. It is going to be a quite interesting event when the manufacturers of Brand Y, that seemingly unlimited line of inferior products, fight back with a program that is ninety per cent effective for ninety per cent of the consuming public.

One of the most interesting impossibilities has been the work on content. The origin of programming seems characterized by a combination of scientific modesty and not much optimism. While it was agreed that programmed instruction would be beneficial wherever extensive practice with rote materials was required, there was little except theory to suggest that elaborate concepts, aesthetic judgment, creativity or similar skills would ever be reduced to programming. Today, however, work on many of these areas is in progress. Not only does it seem possible that these complex kinds of performance can be taught, but it is likely that the procedures used in preparing programs will generate truly capable graduates with far more assurance than present methods. In other words, it now does not seem impossible that those objectives central to modern concepts of education could be taught effectively and efficiently by programmed means.

Why anything but simple factual knowledge, and perhaps well-defined principles seemed beyond the capabilities of programming unfortunately reflects a belief that the processes of education and training must remain forever outside the realm of empiricism. Instruction has been the object of far too little research and far too much discourse. Mediocrity has not been eliminated from the classroom despite the extent to which it has been challenged by those teachers and administrators who have been seriously critical of the accomplishments of our instructional systems. For instance, the classroom teacher hopes to produce creativity and similar course outcomes; but she is typically at a loss to describe what she does to assist the student in being creative, aside from being permissive and not imposing too much structure. Yet, she feels this and similar categories of instruction are her areas of greatest competence and those which could never be dealt with by programmed instruction. Instilling routine facts, on the other hand, is a task at which most teachers are successful; so much so that activities of this kind are not considered a challenge. But, just why this level of instruction, which can be presented successfully by a teacher, should be allocated to programming is not at all clear.

Programmers, just as teachers, are rarely excited by the opportunity to provide practice exercises, in arithmetic, language vocabulary, or irregular spellings. Although there is considerable discussion as to the outcomes desired from practice on these subjects, the methods for assuring mastery are both varied and well known. The chances of producing a truly significant advance in instructional technology for rote subjects (one which will produce a substantial increase in the effectiveness of instruction) are relatively remote. On the other hand, the possibility of utilizing the methods inherent in programming to discover some reliable process for instilling insight, developing interpretive skills or producing appreciation represents a very realistic goal for the programmer.

If the methods employed by the programmer were typically used in the classroom, it would not be so unusual to consider creativity or originality in the same light as physics or history. To begin with, emphasis must be placed upon the product and not the process of instruction. Active discourse between the teacher and pupil is frequently identified as one reason why programs will never entirely replace teachers. Yet, the objective of classroom discussion is never made too clear; it is supposed to be inherently a good thing and a desirable educational process. Active discourse is also supposed to promote critical thinking and analytic skills. Because this objective is certainly a reasonable one for education and for many kinds of training, the programming strategy which might be used to achieve critical thinking and analytic skills will serve as a suitable example of the approach taken in programming complex behaviors.

It is important to determine the characteristics of criterion performance first; that is, how it can be observed and the ways in which it might be assessed. There are many who might contend that critical thinking and analysis cannot be objectively defined, described or measured. The failure to establish what is meant by these skills is an admission of defeat since without some means of determining the presence or absence of relevant responses (regardless of how subtle they might be) there is no way of establishing that the success of instruction is greater than no instruction at all. This predicament applies equally to the classroom teacher and the programmer; neither is in a position to verify the effectiveness of instruction without some means of observing the outcome. Criteria performance can be described objectively in a variety of ways. One might look at the conclusions drawn by the student after being exposed to an argument, the sequence of questions or comments he verbalizes during a discussion, his analysis of written material, or any other student behavior, product, or combination of behaviors and products. Which objective or group of objectives is selected is only important to the nature of the outcome, not the method of instruction.

Once the objectives have been decided and once some empirical procedure for determining whether or not they have been achieved has been selected, the programming process can begin. To devise an instructional sequence, the programmer attempts to utilize what the students already know and gradually, by adding only one increment of skill at a time, promote increasingly acceptable performance. In the case of critical thinking and analytic skills, the programmer might begin with any of a number of strategies, trying one after the other, until he is convinced (on the basis of the empirical evidence of the success or failure of the materials) that he has not only an acceptable but fairly optimal approach. He does not decide on a process first and then stick with this process regardless of the results obtained from student tryouts. Instead, he is willing to concede the inadequacy of his first, second, third, or even fourth attempt so long as any significant portion of his tryout students fail to exhibit the desired terminal performance.

One strategy the programmer might try is the classroom technique of active discussion. There are at least two reasons, however, why he might not give much priority to this approach. First, he has no reason to believe the technique has led to more than token or chance success in the classroom. Second, the approach is unwieldy, not easily automated, and difficult to implement. Instead, the programmer is apt to concentrate on an approach which can be individualized to the extent that each student can independently proceed through the instruction at his own pace and without outside assistance. These requirements are not necessary; of course, they may make his task a more difficult one. However, the programmer is likely to aim toward this form of instruction because of its potential economy and wide applicability.

It is not at all necesary to duplicate the process of the classroom to produce the same product. In programming critical thinking, one approach might be to begin, not with the production of an argument, but with instruction designed to enable the student to discriminate between good and poor arguments. After this judgmental skill has been perfected, erroneous or inadequate statements of increasing difficulty can be given to the student for him to edit. Finally, he is given the opportunity to prepare an argument from the beginning. This procedure of developing skills in the sequence of first judge, then editor, and last producer is the reverse of those generally used in instruction. In technical writing, for example, only the best writers become editors and only the best editors become judges. By reversing the usual ordering of skill development, it is possible to instruct a writer who initially prepares a passage and then continues to edit it until he is satisfied with the passage in terms of the judgments he has already learned. This approach, which is only one of several the programmer might try, has the additional advantage of permitting each student to maintain an individual style of writing, since he has learned how to judge productions of many different styles and reflecting a variety of content. Every student could be different, but well within the range of excellence established as criterion performance.

An instructional process similar to the one described could be duplicated by the classroom teacher; but the difficulty inherent in instructing many students at once would largely preclude individual rate of progress or the systematic improvement of instruction on the basis of the details of student tryouts. At best, the teacher would identify and carefully record what responses the student should make at each point in the instructional process, what kinds of assistance seemed best, what practice material should be used to insure the greatest possible breadth for the skills being learned, and what sequence appeared to be optimal in presenting these various components. The resulting collection would be a draft program which, considering the amount of work that had been devoted to it, should then be tried out and made available as the program it is.

Programming is far from a magical process; it cannot solve problems other than those it is capable of solving. Instruction, whether offered in the classroom, by an individual tutor, over television, with books, or through programs, is basically an effort to arrange the student's environment so that the desired learning will occur as easily and rapidly as possible. Learning can occur under almost any set of circumstances; in fact, large amounts of learning take place without the assistance of formal instruction of any sort. Experience, which might be defined as the making of relevant responses under appropriate circumstances, is learning. The contribution of instruction is to arrange for the necessary kind and amount of experience without leaving it up to chance. Programming simply is an effort to condense the necessary experiences as concisely and systematically as possible so as to insure learning will occur. Viewed from this framework, no learned human behaviour is unamenable to programmed instruction and the benefits it potentially affords.

In conclusion, programming the impossible has only been made possible by the fact that the effectiveness and efficiency of instruction are not all most people want them to be. Programming is far more than a tool of education and training. It is a new approach which has the promise of providing all students the opportunity to gain more from the instruction they receive so that they are better prepared to cope with the increasingly complex world in which they live.

A DIALOGUE BETWEEN TEACHING AND TESTING

Thomas F. Gilbert

Thomas Gilbert stresses the paradoxes that achievement tests can be both valuable and useless at one and the same time, and that traditional teaching methods can both increase and decrease individual differences. He clearly illustrates that a "test of knowledge" should be sensitive to many different aspects of learning, not just one cut-and-dried textbook ritual which is stamped "knowledge". He shows that acquisition of knowledge is often overlooked if application of certain techniques in demonstrating this knowledge is faulty. Too many students are graded on their expert or inexpert application of these techniques; their vast knowledge of a subject cannot be applied, and the result is "failure" of a course of study.

Tests of achievement present a paradox. On the one hand, traditional tests appear to obscure individual differences; on the other, traditional tests seem to magnify and exaggerate individual differences. The paradox has a solution, however, and it shows both cases to be true. The solution also demands that we depart from traditional procedures for constructing and interpreting our tests.

Tom, Dick and Harry are three real and not imaginary students. We give them a test of long division, a subject in which all have had instruction. The test has very high reliability and validity, and the stamp of approval of 50 licensed psychologists. It is administered under the most careful conditions. All three boys are at the peak of attention. Tom and Dick both score 50 percent on the test, and Harry makes a perfect zero. Obviously, Tom and Dick represent individuals who do not differ, and Harry clearly doesn't know a thing about long division.

Odd, for I happen to know that Harry can perform with speed and accuracy more than 99 per cent of the operations of long division, and I also know that Tom and Dick missed entirely different problems on the test. And no one, neither Tom, Dick, Harry, nor our 50 learned doctors, cheated.

What happened is simple. Tom failed half of all the long division problems. Dick failed the other half, and Harry knows every operation of long division but one: when he sees a problem stated, 75 ÷ 15, he persistently makes the error of putting the dividend outside the long division bracket and the divisor inside. In every other respect his performance is perfect.

Now we give the test to Harry's twin brother, and he scores 100 per cent. This completes the demonstration. Our test has obscured the great differences between Tom and Dick, and it has exaggerated the small difference between Harry and his brother. There are no tricks here. How can Tom do any division if he doesn't know all the operations? When he multiplies and get a product that is a multiple of ten, he is confused because he hasn't learned to treat zeroes like other numbers: "put down zero and carry one" doesn't make sense to him, although he is at home with "put down 3 and carry 6." Nor can Tom subtract from zeroes. Dick, on the other hand, has a different set of problems. He doesn't know what to do if the first subtraction gives a remainder which the divisor goes into less than one whole time. You can see that there are all kinds of ways to fail at long division, but all of them do not apply to every problem. Dick knows some of these ways, and Tom the others. Do not listen to the arguments that Tom, Dick and Harry are merely unusual statistical events and that the test works on the whole. Nonsense! That has nothing to do with our problem and is only the old siren call to the bliss of statistical ignorance. There is a purpose for which our test is nearly perfect and of great potential use. There is another purpose for which it is useless and, indeed, can be damaging and downright subversive to the ends of education.

So we have a test that both obscures and exaggerates individual differences. Is the test a good one? The answer is both a decisive "yes" and a definite "no". We will soon see why, for there is a more general rule that will permit us to resolve paradoxes such as these, and that will help us make more intelligent decisions about the use of educational instruments.

But first we shall examine two more apparently contradictory propositions: (1) traditional teaching methods increase individual differences: (2) traditional teaching methods decrease individual differences.

The first of these propositions should be easy to defend; I could even appeal to the authority of the 50 learned psychologists. I believe that 20 years ago it was the right answer on a psychology test to say that practice in learning a skill increased individual differences, and recently I discovered that that answer is still graded as correct. With training the smart evidently get smarter and the dumb get dumber, at least by comparison. Let Tom, Dick and Harry illustrate.

After their long division test it became clear that Tom and Dick had potential, but 50 per cent was insufficient realization of it. Fortunately for Tom, the teachers discovered his difficulty and began to give all the low scoring students drills in handling zeroes in arithmetic. Tom and Dick worked many long division problems requiring subtraction of zeroes. Of course Tom had to struggle while Dick breezed through the extra drills, but Tom finally understood zero subtraction. Poor Harry was socially passed, and his twin brother began to experiment with new ways to do long division, for he added when he should have subtracted, and multiplied when he should have divided, and he tried various combinations of number games. Some of these superstitious games gave him by chance, for the first time, right answers, and naturally he took to these games as a race track tout takes to curious betting combinations. The result: Harry ceased to know long division.

After a time our test was administered again. Tom made a 100 per cent, having mastered his zero problems; Dick made 50 per cent again, and you can imagine his surprise and depression since he had whizzed through the practice problems which Tom had struggled over. Harry improved, getting 10 per cent, and his scratch paper looked like a numerologist's notebook. Harry's brother was excused from the exam since he had been placed in a special class for overrated students. The standard deviation of the test has increased since the first administration, yet this statistic fails to reflect the even greater differences produced by our teaching scheme. Surely this successfully defends the proposition that teaching can exaggerate individual differences.

We see still greater individual differences by examining what eventually became of the three boys and Harry's brother as a result of their division training. Dick's 50 per cent so affected him that he quit school and became a juvenile delinquent, cheating the society that cheated him. Harry's superbrother ran into a snag in calculus and gave it up because his superiority in long division was comfortable enough; he ended up as a government bureaucrat who gleefully scrutinizes research proposals for failures to meet this or that mechanical formality, particularly with respect to divisions of the budget. One hundred per cent Tom became a small business man who now appreciates the slow accretion of numerical gain. Poor Harry pursued his hapless attempts to solve long division and would have become an astrologist had his family not been opposed to the occult. In time, Harry became a mathematical genius, for his strange play with numbers led him to develop whole new formulations of mathematics that require, in their parsimony, no long division at all. Alas, he still cannot perform long division, and his twin brother has never let one of his unusual research proposals get by that critical bureaucratic eye. Certainly, individual differences have been produced.

The account of the teaching of Tom, Dick and Harry isn't imaginary, nor is it atypical. However, this account of the resulting careers of Tom, Dick and Harry, although not imaginary, is atypical. A more representative account will defend the second proposition that traditional education discourages individual differences.

Actually it came to pass that Dick achieved 100 per cent in the next year. Harry finally got 100 per cent in his freshman year at college. And Tom's earlier 100 per cent victory over Dick was a Pyrrhic one; as he struggled with long division he missed out on dependent clauses and semi-colons, which he didn't master until his senior year. Harry's twin brother, however, did run into a snag in calculus and was able to find consolation in his achievements in long division and sentence diagramming.

For all three boys, and Harry's brother, there operated a common factor. The rules of the mechanics of reading, writing, and arithmetic became the focal points of success and failure in the world of adult rituals. The boys all passed from expressive childhood into oppressive adulthood, from scrawling on bathroom walls to reading printed regulations that grownups hang in public places, and they came to believe that a man who can not spell well can not write well. Native wisdom came and went and inchoate knowledge lingered. In short, they all became bureaucrats, government or otherwise. That is what really happened. Individual differences were discouraged. So hard it is to teach the human the elementary that he tends to become dedicated to it, and obliterated is the individuality potential in his otherwise superior animal goods.

Paradoxes exist only when we are talking about two different things as if we were talking about the same thing. This is precisely the cause of the paradoxes we consider here. There are two ways in which individual human repertories can differ, and tests can be sensitive to one and not to the other; teaching can affect one without affecting the other: (1) we can measure the number of operations missing from, or existing in, a behavior repertory, or (2) we can measure the effects a behavior repertory has upon the environment. I will illustrate.

Harry made zero on his first test, yet he knew 99 per cent of the operations of long division. If the test were measuring what he knew about long division, if it were assessing the operants established in his repertory, he would make a score of 99. Clearly the test was not measuring the operations of mastery achieved by Harry, although it is called an achievement test. We have already examined the grave consequences that fell upon Harry when his teacher interpreted his test score as a valid measure of what he knew about long division.

But look at Harry's test score from another point of view. The test was graded by counting the number of correctly completed problems. For all of Harry's skill in long division, he was unable to produce the final product required of mastery; his achievement was as useless as that of one who had achieved nothing at all. He had acquired much but accomplished nothing. Regarding the social usefulness of Harry's repertory, the effect it can have upon the environment; the zero test score is perfectly valid. Anyone who needs right answers from long division would have no business employing Harry, and if the test score had reflected what Harry knew about long division rather than the value of his knowledge, it could have badly misled a potential employer.

It should be clear from this that the makers of achievement tests owe it to their customers to tell them what aspect of the behavior repertory the test scores distinguish. I suggest that achievement tests carry one of two names to indicate this distinction. *Acquirement* tests would yield scores that reflect the degree to which the operations of mastery have been acquired; *accomplishment* tests would measure the value of a repertory. (These two words are the synonyms of achievement appropriate for the required distinction. Acquirement connotes achievement produced by learning; accomplishment has the added connotation of acquirements that are useful in social intercourse.) Our long division test is clearly one of accomplishment, but few achievement tests are this pure, for they uncritically confound the two aspects of individual differences.

Let us examine other examples of the confusion between acquirement and accomplishment. You say that you know nothing about bank tellering; but this is not true. If you examine all the operations a bank teller uses to balance his books you will find that you have already acquired most of them. Nevertheless, the few operations you have not acquired prevent you from accomplishing the objectives of the teller's job. In terms of what the teller and you know about his job, there is very little difference between you; in terms of the value of what you know, you are worlds apart. I say I know nothing of marksmanship, but examine my behavior when I attempt to imitate a sharpshooter: so small are the differences between my actions and those of the master that I can fool you until I fire the gun, and even then I don't miss very far. But a miss is as good as a mile, and the value of my repertory is miles apart from that of the sharpshooter's.

A small change in acquirement may produce an enormous change in accomplishment. A minute change in the way I grasp a golf club may more than double the effectiveness of my repertory. And if someone had shown Harry that he was confusing the dividend and divisor, he would have immediately become a division expert. The kid who failed physics knows almost all there is to know about physics, but his accomplishment is worthless.

Now let us examine the meaning of individual differences for educational practice. It should be an agreeable conclusion that our long division test is not appropriate as a guide to teaching, and that it is potentially quite dangerous. Education is charged with producing accomplished citizens, but acquirement is the means to this end. Here the egg must precede the chicken, for acquirement is the only route to accomplishment. It may be a cause for concern to some that measures of accomplishment predominate in educational achievement tests.

The most important error fostered in educational thought by the failure to distinguish systematically between acquirement and accomplishment has been the overrating of individual differences in acquirement. Among students of similar age and culture, differences in acquired repertories may be small, as they usually are when compared with differences in accomplishment. But accomplishment impresses us more than acquirement, and the effect of confusing the two is to make us believe that differences among behavior repertories is much greater than it actually is. Since a technology of education must concern itself directly with acquirement and not accomplishment, it follows that we are likely to suppose that a genuine technology is extremely difficult to attain, for it is easier to arrive at a technology if its subject matter is relatively homogeneous. It is because behavior repertories of human beings are strikingly more similar to each other than we are accustomed to think that a technology of teaching was easier to develop and came about earlier than we had expected.

Reconsider individual differences among long division repertories. While Tom and Dick missed half the problems on the test, they actually are able to perform many more than half the operations. The operations of long division are numerous, if we consider those behaviors which must be separately learned. They consist of such things as writing the number six, writing the number seven, treating all two digit numbers as larger than all one digit numbers, treating the number three as larger than the number two, treating the number nine as larger than the number five, substracting zero from four, subtracting eight from ten, multiplying three by 14, estimating the partial quotient of 89 when divided by 17, setting up an algorithm, distinguishing the tens column from units column, arranging successive estimates of the quotient from left to right, and so on. The student who fails to acquire any one of these operations will suffer serious consequences for his ability to demonstrate his accomplishment. But we can see that Tom and Dick, who made 50 per cent on their test, must have acquired 95 per cent or more of the separate operations. So Harry, who knew 99 per cent of division, made a test score of zero. If we had known precisely what it is that these boys did not know, it would have been much easier to teach them than we had expected it to be.

What I have said is that differences among behavior repertories are small and that, at any given age and school grade, the students will already have acquired most of the elements of mastery of a course of study. Added to this, the components of mastery which the students have not acquired tend to be much the same from student to student (a little thought will convince the skeptic of this). Now we have a picture of individual differences quite at odds with the traditional conception. Our subject-matter—the repertory of students—is considerably more homogeneous than we are accustomed to think. The differences are tiny, but the effect of these tiny differences can be dramatic; and we are more likely to see the effects of these differences than the causes of them.

A third consideration will lead us to view individual differences in acquirement as almost, though not quite, inconsequential. If we go back in time to where Tom, Dick and Harry first began to study long division we will see that the differences among them were even smaller than they were after instruction. They all would have made zero on the division test at that time. All knew how to estimate quotients, all knew how to multiply and substract, except that Tom couldn't handle some zero problems. Dick and Harry are ready for instruction and Tom needs only a small amount of work on subtracting zeroes. When Tom's remedial work is accomplished, we are prepared to instruct them. Analysis tells us that the boys all know nearly everything about long division except the order and format in which they are to carry out the acts of estimating quotients, multiplying, and subtracting. It is important for this point to be very clear: if the boys are ready for long division instruction, they each know all the component acts of long division, and it is reasonable to assume that none of them know the correct sequence of these acts. With respect to this subject matter the boys are virtually identical; Tom is unable to subtract as fast as the rest, Dick can estimate quotients faster, Harry is more rapid in multiplication, and Harry's brother is less careless than the others and perhaps more eager; but all know the component operations and none know the division sequence. Their differences are a small part of the total repertory being considered. As we have seen, these small differences can have great consequences if we aren't careful. And care in education need not be as difficult as it seems.

What happens if we are not careful? Just as we have seen. We will teach the boys in such a manner that they will differ greatly in accomplishment but only slightly in acquirement.

PROGRAMMED INSTRUCTION COMPARED WITH AUTOMATED INSTRUCTION

Norman A. Crowder

Norman Crowder, in his usual provocative style, points out that about the objective of programmed instruction there is unanimity: more effective and efficient learning; about the means, confusion, and often invidious contention, reigns. The basic difference rests with the purpose of student responses. The linear approach views student responses as essential to the learning process and is thus greatly concerned with the sentence-by-sentence structure, or the microstructure, of the education process. Intrinsic programming, on the other hand, deals with the macrostructure of instructional materials; student responses are feedback mechanisms which determine the course of the educational process. As such, intrinsic programming is a truly automated process since presentation of material is directly controlled by the activity of the student. Linear programming is indeed automatic but not automated since what the student does, does not affect the course of the process.

Every now and then a well-meaning acquaintance of mine will say to me, "Norman, why is it that you perversely insist on quarreling with the linear programmers? Why don't you seek a compromise, a middle position that will accommodate all point of view? Or better yet, why don't you just agree with everybody?"

For the benefit of these peacemakers, who presumably otherwise would not get their reward until they get to heaven, I want to report that I recently had the pleasure of listening to Dr. Skinner and agreed heartily with something that he said. What he said was that, at the present time, the field of programmed instruction is in a state of appalling confusion. I think this is true and I am anxious that this confusion be ended. It is just for this reason, however, that I have not placed great emphasis on finding middle grounds or median positions that will represent all points of view. To do so would be quite misleading. The way to end the confusion is to state each of the various viewpoints clearly, pointing out and contrasting the differences in approach, assumption, and resulting technique. Surely within the scientific community one could expect to make such comparisons without being accused of invidious intent, or even to argue for the greater appropriateness of one assumption over another without being considered merely contentious. At least one hopes this is so, for it is only by such comparison and contrast that the confusion, of which Dr. Skinner is not alone in complaining, can be ended.

There are a great many different things being talked about under the heading of programmed instruction. All of the people engaged in the field seem to have as their objective a better educated student, usually without much intercession by a live instructor in the educational process. There are wide differences, however, in the things that people seem to feel important in bringing this result about. Thus, for example, I find Susan Markle quoted as saying that the distinguishing feature of programmed instruction is the try-out of materials. Now certainly it is characteristic of programmed instructional materials that they are easier to try out than are other prepared instructional materials, but this characteristic does not define for the uninformed what the processes are that are relied upon to induce learning.

Similarly, I have the impression from Robert Mager and others that they are more concerned with clearly specifying the objectives of the instruction than with the techniques of instruction. No one will quarrel, of course, with the desirability of clearly specifying educational objectives, and programmed instruction does make it easier to correlate the objectives with the actual instruction. But the desirability of clearly stated educational objectives is not peculiar to the field of programmed instruction.

Related to those who place great emphasis on the clear setting of objectives are those who see programmed instruction as a means of introducing curriculum reform, and rely on the improved curriculum to produce superior results. Again, it is true as a practical point that programmed instruction is a convenient means of introducing curricular changes, since the requirement for retraining of instructors is lessened. It is also true that the detailed attention that the subject matter receives in being programmed may lead to curricular reorganization; in fact, it usually does. But the genius of programmed instruction does not lie in curricular revision.

Finally, we find in the literature a number of what I would call propaganda definitions, such as: "Programmed learning is the organization of instructional materials in sequences optimally organized to produce student learning". Such a definition is impressive, but it does not define very well what principles are to be used in the organization of material, or what process is to be relied upon to produce learning. I wonder, when I read such definitions, what teacher ever deliberately organized his materials in any other way than the one which he believed would optimally promote student learning.

All of the things I have just discussed—the opportunity for careful preliminary try-out of materials, the possibility of defining educational objectives clearly and of making the instruction consonant, point by point, with these objectives, the opportunity to revise the curriculum independent of a supply of experienced instructors, the occasion and opportunity for detailed analysis and reorganization of the subject matter—are valuable ancillary features of, or auxiliary benefits to be derived from, programmed instruction. But the defining feature of programmed instruction does not lie in any of the things so far discussed, but in the process whereby the instruction itself is to be brought about. But it is here, at the heart of the subject, that we find the greatest difference of opinion among current practitioners of the art. Hence, the confusion in the field. It was with the intention of making the basic theoretical difference quite explicit that I chose as a title for the presentation "Programmed instruction compared with automated instruction".

All forms of programmed instruction depend on the individual student's being more successful in using the newly prepared materials than he has been with conventional text materials. To bring about this more successful independent use of materials, two quite different possibilities have been set forth to be exploited, one chiefly by Professor Skinner and the other primarily by myself.

Professor Skinner proposed to exploit the present work in learning theory as a guide to the improvement of what we might call the microstructure of the instructional materials. Specifically, he proposed to so structure the instructional materials that, at each step in the process, explicit and systematic use is made of existing response tendencies to elicit the "correct" response to new stimuli. This correct response, so elicited, is confirmed and thereby reinforced and so learned and becomes part of the now-existing response repertoire which may be used in the next step, and so on.

Presumably I need not elucidate this model further, since it is the basis of the linear style of programming and so is familiar to all; I only wanted to point out that the characteristic feature of linear programming is an attempt to improve the sentence by sentence effectiveness of written communication, the microstructure, if you will, of the learning process. Beyond the peculiarities induced by the requirement to elicit and reinforce the student response at each step in the process, the resulting linear materials are, in effect, conventional in structure and intended use.

I have dealt elsewhere with my reasons for believing that improvement in instructional materials, which is limited to the microstructure of those materials, can meet with only limited success, and will not rehearse those reasons in detail here. Basically it comes down to the problem posed by human variability. The more carefully we fit the microstructure of instructional materials to a single individual, the less good the fit must be for a second individual. We can attain the illusion of fitting everyone if we judge only by the student's success in giving the correct responses, since in general a good student can do what a dull student can, but surely this is naive. But I stray from my point, which is this: what I had proposed to exploit to improve the effectiveness of instruction was the possibility of testing the student quite frequently and using the test result to determine what to do with him next. The intrinsic programming technique, which in essence is the automatic use of the student's response to direct him to appropriate material, makes it possible to manipulate the macrostructure of the educational process completely and automatically with a device as simple as the "scrambled book".

Numerous advantages arise from this ability to automatically vary the instruction on the basis of the student's response. Direct evidence of the student's readiness to attack a new point is obtained at each step, independent of the student's evaluation of his readiness. Anticipatible errors can be provided for in the answer choices provided and appropriate remedial material prepared and automatically presented. Most important of all, in my opinion, is the fact that the questions set for the student may be of any level of difficulty we judge to be desirable, i.e., since we have a means to deal specifically with errors, we need not fear that errors will be made and thus can write programs which exert an upward pressure on the student's abilities, rather than forcing all students through the path determined by the dullest. But again, I am straying from my main theme, which was the sources of confusion in the present discussions of programmed instruction.

The basic difference, which so often goes unrecognized, between linear and intrinsic programming is the fact that each is concerned with a different part of the educational process. The linear programs are directed to improving the microstructure of the process, i.e., they seek methods whereby the student can be made infallibly to learn at each step. The intrinsic programmers are not convinced that the microstructure can be sufficiently improved that the success of each step can be assumed, at least at tolerable cost in redundancy, and so are interested in the possibilities of manipulating the macrostructure of the process, by continually testing the student and utilizing the test result to vary the materials presented to the student. Nowhere can the essential difference in the two techniques be seen so clearly as when we ask the programmer's purpose in eliciting a response from the student. The linear programmer elicits the response because he believes the making of the response is an essential part of the learning process. Once the response had been elicited, it has served its purpose (in a linear program) and thus no further use is made of it. In an intrinsic program, the programmer elicits the response in order to see if the student has learned, because this information will be used to determine whether the next point is to be presented, or whether additional material on the previous point is required. Perhaps these considerations will make it clear why I am a little discontented when I hear someone summarize the field with the statement that the basic difference between a linear program and an intrinsic program is that the one uses a constructed response, the other a multiple choice response. The basic difference is not in the form of the student's response, but rather in the purpose served by requiring him to make a response at all.

A truly automated process is characterized by the fact that the result of the process is continuously sampled and the sample result used to control the process. The "feedback" characteristic of an automated process is not applied to the work piece, but to the processing equipment. I suggest that in this sense, a linear program cannot be considered an automated instructional process, since what the student—the work piece, in this case—does, does not affect the course of the process. An intrinsic program is, of course, an automated process in this sense, as the presentation of material to the student is determined directly and continuously by the activity of the student himself, and it may be that no two students will take the same course through the material. The linear program is an automatic process, in that it operates, in principle, untended, but it is not an automated process because it is not self-correcting.

Again, let me say that in drawing this distinction between an automatic process and an automated process, I do not intend any unfavorable reflection on the simple automatic process. I only wish to make the essential difference between the character of the automatic linear process and the automated intrinsic programming clear. But lest I sound too reasonable, let me say that if it takes a fully automated, self-correcting process to perform so simple a task as rolling sheet steel from fairly uniform steel billets, I do not believe that a less flexible process will serve a useful range of educational purposes.

PROGRAMMED INSTRUCTION IN PERSPECTIVE

Carlton B. Downing

Carlton Downing points out that the greatest strides in the development and use of programmed instruction has taken place in the military services. Industry is also showing great interest in its use. But in the public schools, progress is moving slowly. Producers of programmed materials made a mistake in programming whole courses instead of small sections of courses. Programmed instruction has suffered as much from its friends as from its detractors. Better presentation and more empirical evidence could speed its acceptance. The by-product of programming, better conventional teaching, is one of the most promising aspects of the use of programmed materials.

The subject of programmed instruction in perspective can be approached only with some temerity. The title implies a global omnicience for which the author's credentials scarcely qualify him. Therefore, this paper will limit the discussion to a brief overview of the growth, present uses, and the prospects for the use of programmed instruction.

Probably the greatest strides that have been made in the development and use of programmed materials for teaching have been in the military services. Two of the major military centers for the development and use of programmed instruction are Randolph and Lackland Air Force Bases of the Air Training Command. Programmed instruction within the Air Training Command has been favored with sympathetic administration, competent leadership, and adequate finances. The number of frames written, the number of training skills taught with the assistance of programmed materials, the number of program writers trained and the amount of outside expert technical assistance sought and secured support the obvious conclusion that these bases are not only leaders in the development of programmed instruction for the military services, but that they are also actual leaders in the development of the art of programming itself. The names of those providing technical assistance to the development of programs in this area in recent months reads like a roll call of the leaders in the art of programming. The effort expended, the quality of leadership and level of administrative support point to continued vigorous leadership in the art of programming in the military services.

The second area of promise is in the expanded use of programmed instruction by business and industry. The roster of companies using some phase of programmed instruction for training new employees includes most of the major corporations of the nation. These companies are also using the services of a growing number of organizations that provide technical concultant services in the analysis of skills and the production of programmed materials.

The National Office of the National Society for Programmed Instruction (NSPI) is a vantage point for viewing the growing interest of training directors in the use of programmed materials. Inquiries have been received from city owned utilities, banks, hospitals, an insurance company, a hybrid seed-corn producer, and a clothing manufacturer. It seems safe to predict from these inquiries a broadening interest in the use of programmed materials in the smaller companies. The acceptance of programs for training in business will be determined by one hard and fast business yard stick that it must teach the necessary skills more economically and more efficiently than other methods.

The third area to be considered is the use of programmed material in the school classrooms. Honesty compels the admission that the use of programs by teachers has not increased at the pace many would like to see. One writer and program producer says ruefully, "The schools are enthusiastically NOT using our materials." Several reasons for this slow acceptance are evident. Administrators and teachers are conservative because society expects them to be. Historically, parents have shown considerable reluctance to having their children as experimental subjects. It is usually accurate to predict that any innovation in teaching will have slow acceptance. Innovators in schools have high marks for low tenure.

It appears that early producers of programs for use in elementary and secondary schools made a serious error in judgment when they chose to program whole courses rather than units or modules of courses. The decision to teach a semester course with a program implies the acceptance of the concept of each student progressing at his own rate of learning.

It should have been easy to predict that the use of student-paced programs would lead to difficult administrative problems. The easily foreseen problem is that of what to do with a student who completes the year's course in three months, or even sooner. Principals and teachers know what to do for these students, but the concept of each student progressing at his own rate may demand smaller classes, more teachers, more equipment, and materials, and more financial support than most communities appear ready to provide. Present also is the fact that no good programs are available for many school subjects. Teachers have difficulty in finding time to write their their own programs without neglecting other duties.

The cause of programmed material in schools has suffered from its friends as much as from its detractors. Numerous speakers have been inept and have exhibited a vast lack of understanding of the practical aspects of teaching. The case for programmed instruction deserves better presentation than it has had. Perhaps the single greatest deterrent to the acceptance of programmed material for use in the classroom is the dearth of empirical evidence to prove its efficacy.

While the acceptance of programmed material in the classroom is not a reason for satisfaction, the picture is not all bleak. Some teachers and teams of teachers, encouraged by administrators, have found time to write and use programs. It seems significant that most teachers prefer to write and use modules of courses. School counselors are starting to recommend programmed material for enrichment for able students and for remedial use with students who need it. The use of programs in colleges and universities is beginning to appear in experimental situations.

One of the most promising aspects of the use of programmed material in classrooms seems to be a by-product of programming. But it is one that should be heartening to those who believe in using programmed materials. Reports recur that teachers who use programs begin to apply the techniques to other teaching areas. They give more emphasis to stated objectives, to pupil involvement, and they assume more responsibility for the student's giving correct responses. This demonstrates the soundness of one of the fondest claims of those enthusiastic about programs, that is, they incorporate the principles of sound and effective learning.

The forms for writing programs appear to be in a changing pattern. Complete adherence to a single type of writing frames, be it linear, branching, or other is passing. Writers are beginning to use several approaches on one program. This practice could well lead to more useful programs that embody the best of several methods. Another interesting development has been the inclusion of adjunct material with programs. This inclusion of reading material with frames provides extraordinary flexibility for introducing technical and unusual material with which the trainee has had little or no acquaintance. Writing objectives for technical courses is frequently quite simple when compared with the problems of determining the starting point in an heirarchy of skills. These innovations, this melding of methods, gives promise of better programs.

As a brief summary, the use of programmed material has had its greatest use and has its greatest promise of growth in the military services. The use of programmed material in industry, business, and health services, increases as it demonstrates its ability to reduce training time and costs. The acceptance of programmed material in the vast area of the schools proceeds slowly, but acceptance is more wide-spread each year. Better presentation and more empirical evidence could speed this acceptance. It is encouraging to report that the use of programmed material and techniques by teachers results in better teaching in other areas.

III. Development of Systems Applications

THE SYSTEMS APPROACH TO PROGRAMMING

Roger A. Kaufman

Roger Kaufman points out that the systems approach developed in other industries has considerable value in its application in the preparation of programmed instruction materials. The importance of the system approach in education becomes more critical with the application of programmed instruction. Programmed instruction is only a part or a sub-system of the total educational system which includes school buildings, teacher training, and supervision. Roger Kaufman discusses how the systems approach achieves better programmed materials.

The "systems approach" used in many scientific disciplines has important implications for programmed instruction. What is the systems approach? Stated simply, it is the notion that anything we consider is a dynamic whole constituted of interacting factors or variables. Perceived in this manner, the whole is really more than the sum of its parts. An analogy from physiology points out that the human organism is composed of many parts: structural members, protective covering, organs, and integrating and distribution systems of various types. Each has a job or jobs, and each can be viewed separately and apart from all other parts. Yet, in life, the parts do not function alone; we know that each part has innumerable interactive effects on other parts of the body. The body is not merely a collection of parts; it is a dynamic system. All parts of a system have interaction effects on other parts.

Our total world is composed of systems and subsystems. A programmed course in algebra for 9th graders, like a Mach 3 aircraft designed to fly from New York to Paris in less than three hours carrying 170 passengers, can be considered a system or a subsystem. In a system, each part, or component, has a purpose; it contributes in some measurable way to the total system objectives. To use the systems approach properly, each component must be identified and its function determined. If a system has components whose existence or functions cannot be identified, the system will be relatively inefficient in meeting its mission objectives. Only when all components within a system can be identified and their contribution towards achieving mission objectives determined can it be said that a systems approach is being used.

In designing a system, using the systems approach, we must identify the system objectives, and then consider all of the possible interactions, or interrelations between variables and the ways in which they might affect total system performance.

An automated instructional program may be considered a system, or a sub-system within a larger system. If our boundary of consideration is a programmed course on map reading, our system is the program, a program with specified mission objectives. After the course has been written, validated, and implemented into a curriculum, the program becomes a sub-system within the curriculum system. By using the systems approach, persons concerned with creating programs can more quickly and efficiently fulfill their "mission objectives" of creating valid instructional materials. Actually, proper programming requires that a systems approach be utilized. Let us now turn to the procedure for preparing programmed materials using the systems approach.

Generally, we start with a request for material or a stated requirement (see Figure 1).* We analyze the requirements for the course, generally performing a task and training systems analysis to determine exactly what skills and knowledges the trainee (student) must have when he completes the course and the characteristics of the training matrix into which the programmed course will be introduced. We analyze the student population to determine what behavioral repertoire the students will bring to the course. From the task analysis and student population characteristic data, we set the objectives for the course, objectives which are measurable. From these objectives we derive a criterion test which can be used to determine when we have satisfied the mission objectives, or the extent to which our program has not been completely successful. The next step is to obtain the approval of the training manager or curriculum director since he is responsible for the programmed system when it becomes a sub-system in his total training system. If the training manager is not satisfied with the derived mission objectives and/or criterion test, they are revised. After the training manager's approval, we determine what training methods and techniques are available for performing our mission objectives. Using the data collected from the task

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* This figure is a slight variation of one originally developed by the Training Methods Division of the Air Training Command, USAF.

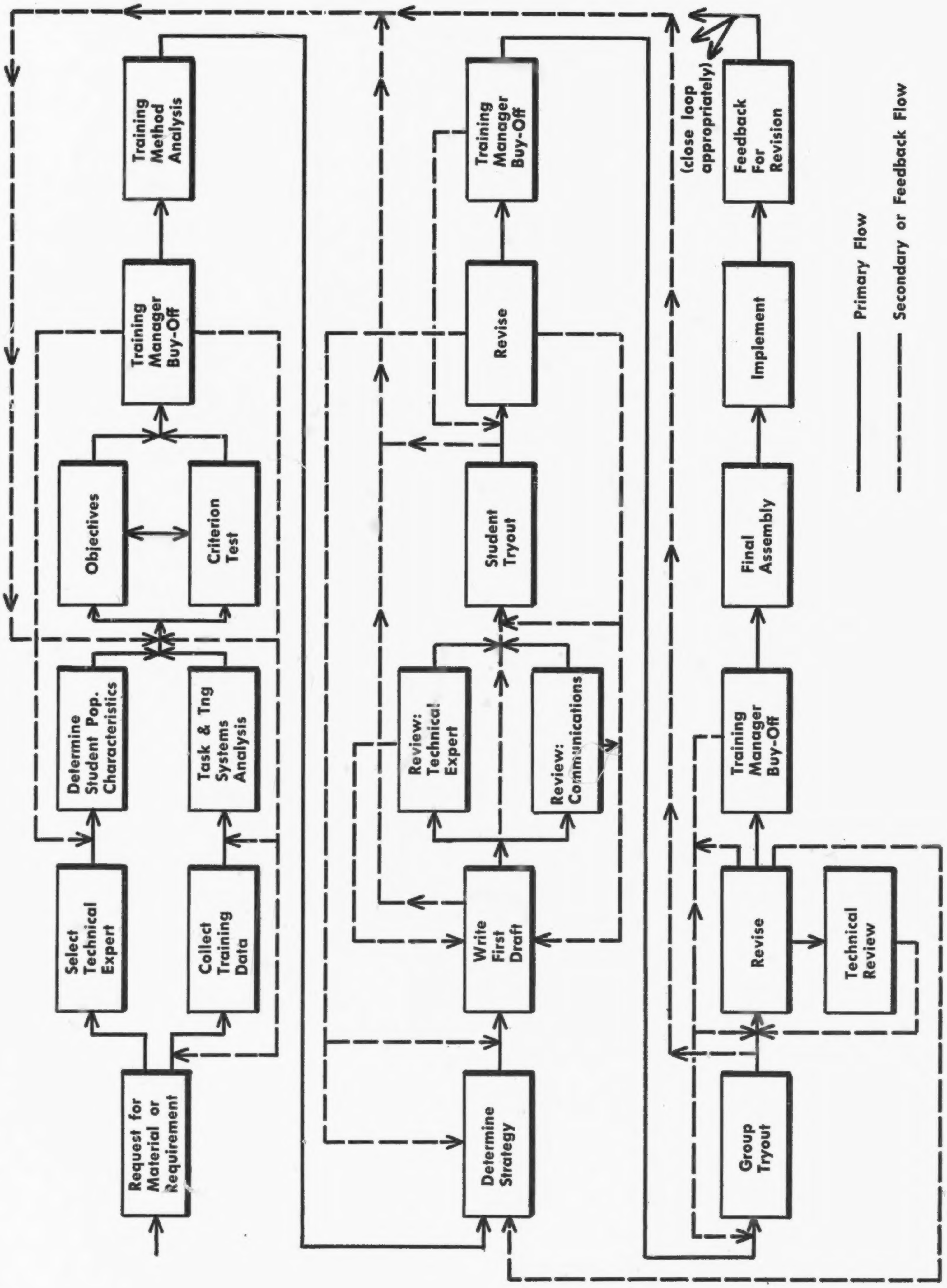

Request for Material or Requirement
Select Technical Expert
Collect Training Data
Determine Student Pop. Characteristics
Task & Tng Systems Analysis
Objectives
Criterion Test
Training Manager Buy-Off
Training Method Analysis
Determine Strategy
Write First Draft
Review: Technical Expert
Review: Communications
Student Tryout
Revise
Training Manager Buy-Off
Group Tryout
Revise
Technical Review
Training Manager Buy-Off
Final Assembly
Implement
Feedback For Revision
(close loop appropriately)
Primary Flow
Secondary or Feedback Flow

Figure 1. Function Flow Diagram for Preparing Automated Instructional Materials
This figure is a slight variation of one originally developed by the Training Methods Division of the Air Training Command, USAF

analysis in conjunction with the objectives, we determine our strategy for creating the programmed course. The first program draft is then written to meet the previously determined system objectives. It is reviewed for technical accuracy and for clarity and communication skill. It is then rewritten and tried on several target population students. This tryout is known as frame or item validation and supplies data for a program revision based on student response data, not conjecture by the programmer or other personnel concerned with the program-system. Frequently, the training manager is asked to review and accept the programmed materials after frame validation and revisions. After approval, the program is subjected to a group tryout. This tryout is a "dress rehearsal" which determines if the program meets its objectives. Generally, a large number of students from the system target population are given a pretest, the program, and then the criterion test. The difference between the pretest performance and the post test performance yields an index of content gain. Based on group performance on the program as measused by the gain scores, the program is revised appropriately. After final approval by the training manager. the program is assembled in final form and put into use.

Ordinarily, one might consider that our systems task has been completed, but such is not the case with programmed instruction. We must continue to collect student response data to improve the program, to enable us to meet our mission objectives more completely or efficiently. The programming system, then, is a closed loop since we constantly feed information back into the system to improve system performance.

In using the systems approach, we have proceeded from a set of specified objectives to the creating of a system, and have done so in an orderly, planned, and controlled manner. We have taken account of all the factors which might affect system performance. We have also taken into account possible interactions between factors. In using the systems approach to programming, we have created a model for system-building. This model should be open to revision as we collect additional data on how to create valid programs. It is a science of programming.

The systems approach is really the formalization of proven techniques for accomplishing complex tasks efficiently. A model for progressing from the specification of mission objectives to the satisfying of those objectives in a planned manner is economically as well as philosophically sound. In programming instruction, the systems approach is valuable not only as a guide for the creation of programs but as a model for the appropriate utilization and integration of programs into a total training situation.

Other models for program creation have been suggested. Skinner has offered one based on conditioned responses. Crowder has offered a model based on human communication interaction. Unfortunately, these models have usually been unable to predict the outcomes of experimental research concerned with the operating characteristics of various program formats. These models, in their current form, presently seem inadequate for forming guidelines for preparation of programmed material.

The systems approach offers an alternative to inadequate theory, or at least provides a supplement until such time as theory matures to the point of providing usable criteria for programming. The systems approach evokes the criteria of functional utility; we select techniques and methods in terms of specific desired educational or training outcomes. We thus shift from a technique orientation to a problem orientation.

The importance of systems approach to training and education has been forcefully enhanced by the requirements of programmed instruction. It might well give rise to an educational technology which will surpass and enhance programmed instruction's usefulness for improving education and training.

By utilizing the systems approach, including the stating of educational objectives and missions in measurable behavioral terms, and by planning the implementation of change through accounting for and manipulation of variables contributing to system objectives, education and training can become an efficient, sensible, orderly endeavor. In the same manner that we constuct a program using the systems approach, we can also plan curriculum units, school units, school buildings, and entire educational systems. Educational and training objectives can and should be quantified. We need to start planning our educational systems around measurable behavioral outcomes, and the systems approach seems to be an excellent model for getting under way.

PROGRAMMED INSTRUCTION AS A SYSTEMS APPROACH TO EDUCATION

Robert E. Corrigan

Robert Corrigan proposes that programmed instruction be conceived of as a form instructional system best suited and designed to meet the ultimate objectives of our educational system. System requirements are postulated to organize and develop the methods and materials of instruction including automatic teaching most consistent with efficient individual learning requirements in both individual and group settings. He further proposes that the underlying philosophy of this system provides the most meaningful rationale to organize, coordinate and direct the efforts of all contributing groups. Applying the proposed systems concept provides a "team approach" with specification of the role and performance requirements for each team member consistent with the established objectives of instruction.

During the past three years, programmed instructional methods have been extensively explored and evaluated at all levels within our national educational system. The results substantiate the positive significance of these methods for education. While educators acknowledge the significance of self-instructional programming methods, they are posing penetrating questions concerning the application of programmed instruction to the broader scope of instructional requirements which face them. A specific realism expressed by the educator is the requirement for both individual and group instruction. Dr. J. Lloyd Trump, National Education Association, presents a plan of action which recommends that 60% of the average 30-hour week be utilized for large and small group instruction, and 40% for individual instruction. His report, and others, emphasize the group or class as the basic instructional unit in our educational system, at least, for the foreseeable future. Our concern in group instruction is that each individual within the group attain his greatest potential level of achievement by our providing the most appropriate instructional and individual learning conditions to insure this.

Educators are asking these questions: (1) how do we meet and satisfy the needs for group instruction?, (2) what is the role of the programmed instruction to meet broad curriculum directives?, and (3) how do we combine the elements of programmed instruction in terms of meeting the realisms for a mass educational system? I propose that programmed instruction be conceived of as a complete system of instruction, best organized and designed to meet the specific objective of efficient individual learning. I believe that the methods of programmed instruction when applied to the design of instructional systems provide the means for resolving the broad scope of instructional requirements which include the need for both individual and group instruction.

The terms "system" and "systems approach", when originally conceived, related to applied methods for increasing the efficiency of overall planning, organization, and coordination in the development of our national weapon systems. The "systems approach" considers each of the many individuals and groups developing a particular weapon (like the Atlas missile) as individual components like cogs in a machine working together to achieve a common goal. This approach requires: (1) defining in advance the job of each person or "cog" in terms of his assigned responsibilities, (2) detailing the task, (3) specifying performance requirements, and (4) stating the necessary interactions and communications to be carried out between groups, each requirement tailored and defined to meet the pre-set system goal. The word system, therefore, suggests an organized plan carried out in detail to achieve a pre-established goal or objective. The goal must be accomplished within set performance limits. Quality of performance is measured by the degree of compatibility or efficiency between those components making up the system in the attainment of pre-established terminal performance objectives.

Now let us apply the systems approach to programmed instruction. Here we are concerned with one common objective, namely, *efficient individual learning* and *performance*. In meeting this objective, we can define three scopes of activity which are performed by independent groups. (Table I.) These groups and associated activities are as follows: (1) the curriculum director and the programmer analyze and develop instructional materials; (2) the instructional environment consisting of the teacher-student-program complex, carrying out the methods and procedures in the instructional process as established by the curriculum director and programmer; and, the administration, supervisory, and parental groups, who, while operating outside the immediate instructional environment, directly, or indirectly, influence the quality of instruction and individual learning. Each will be discussed separately.

The systems model is the contribution of the human factors or human engineering analyst (Table II). He applies the systems approach: (1) to establish design

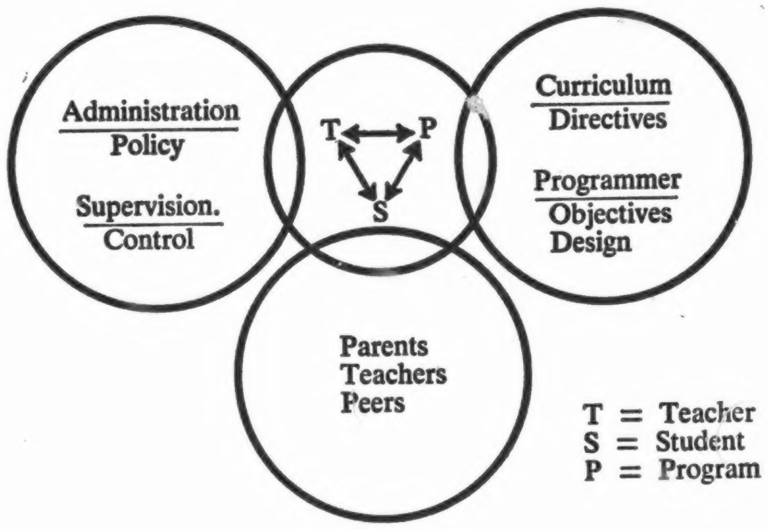
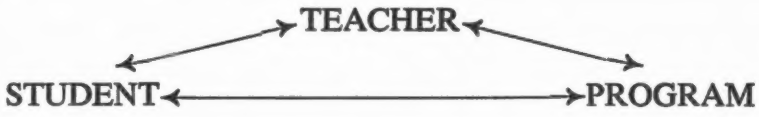

Administration
Policy
Supervision.
Control
T
P
S
Curriculum
Directives
Programmer
Objectives
Design
Parents
Teachers
Peers
T = Teacher
S = Student
P = Program

Table I—Programmed Instructional System Components

specifications for equipment, and (2) to establish operating and training requirements for the man operating the equipment. He must describe and predict performance for the man, design requirements for the machine. This method is called "task analysis." His prime objective is to insure that man and machine are compatible as a unified system.

In an instructional system the "teacher-student-program complex" replaces the "man-machine" system. The programming analyst using the task analysis model follows a continual "try and fit" procedure to "tailor" a specific program or instructional package to meet defined instructional and learning objectives. The problems confronting the programming analyst cover: (1) the curriculum directives and instructional requirements, (2) the learning requirements of the students, (3) the characteristics of the learner(s), (4) the instructional setting, and (5) the models and methods of communication. All these the programming analyst must consider while developing instructional materials.

Individual achievement is the direct outcome of the interaction between the three prime sources which make up the immediate teaching-learning environment.


TEACHER
STUDENT
PROGRAM

Each of the three elements (teacher, student, and program) represent the contributing elements necessary to the instructional setting. While each can be considered alone, we define the teaching-learning process as a dynamic event with each element continuously interacting with the others in an ever dependent relationship. The efficiency of teaching and/or learning is the direct outcome of the quality of the contribution of each of the three defined elements at the moment of their interaction. This is relevant whether we are referring to a student and a program, a teacher and a student, or any combination of these.

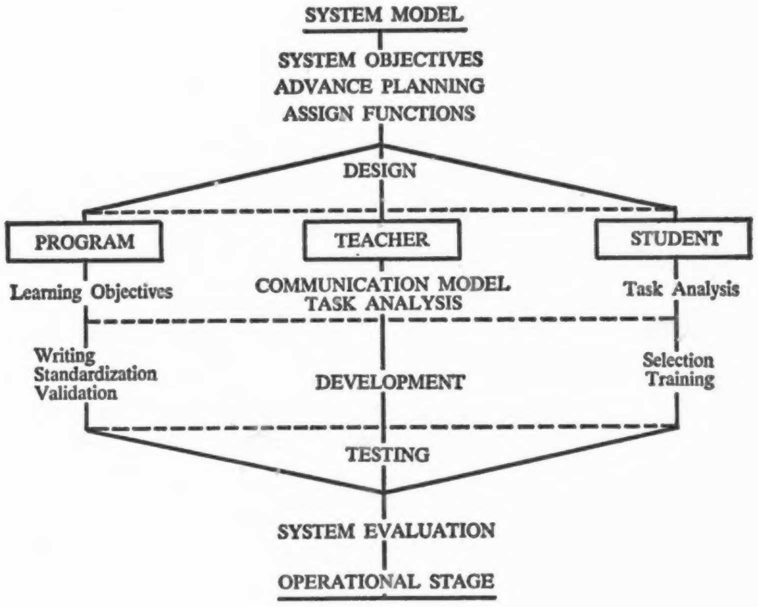

SYSTEM MODEL
SYSTEM OBJECTIVES
ADVANCE PLANNING
ASSIGN FUNCTIONS
DESIGN
PROGRAM
TEACHER
STUDENT
Learning Objectives
COMMUNICATION MODEL
TASK ANALYSIS
Task Analysis
Writing
Standardization
Validation
DEVELOPMENT
Selection
Training
TESTING
SYSTEM EVALUATION
OPERATIONAL STAGE

Table II—Programmed Instruction as a Systems Model

In analyzing instructional and learning processes we must consider all contributing elements influencing system efficiency. Our attention must be directed to the broadest scope to include groups outside the immediate instructional environment. Viewing our educational system as an iceberg, the tip is representative of the immediate classroom. As with an iceberg, the greater supporting groups represented by administrative, supervisory and parental groups, although non-observable, directly influence the quality and efficiency of instruction. It is imperative, therefore, that the role and contribution of each support group be defined to provide peak efficiency. Applying the common objective, student achievement, the required contribution of each can be analyzed and integrated into a comprehensive plan with means established for measuring the quality and efficiency of performance. The underlying guiding principle of the systems approach to education provides this vehicle.

Independent of system components or groups are the requirements and scope of the proposed instructional system. I should like to propose eight requirements of this system.* These are as follows: (Table III).

DESIGN REQUIREMENTS	*DESIGN CLASSIFICATION*
1. Statement of objectives	ORGANIZATION
2. Essential subject matter	
3. Order material in steps	
4. Active student participation	COMMUNICATION and CONTROL
5. Controlled pacing	
6. Two-way communication	
7. Apply learning principles	EVALUATION
8. Performance requirements-measures	

Table III—Design Requirements and Classifications for a Programmed Instructional System of Education

1. The statement of objectives for instruction and individual learning expressed in performance terms.

2. The determination of the essential (minimal) subject matter to meet the stated objectives.

3. The ordering of subject matter into a program format designed to expedite the learning route.

4. Highly individualized student participation on a continuously active basis featuring the recurrent requirement for overt, observable responses to strengthen the learning process and to evaluate student achievement.

5. Controlled pacing of instruction consistent with student performance as measured by the pre-established criteria of learning.

6. Highly directed communication by the "instructor" using the "tutorial" or "coach-pupil" two-way communication model to insure continual and purposeful interaction between "instructor and student".

7. Incorporation throughout the program of those fundamental principles essential to efficient learning, such as:

a. Knowledge of results of performance.

b. Immediate correction of incorrect responses.

c. Purposeful repetition and reinforcement scheduling.

d. Directing the student in purposeful learning sequences with his prior knowledge of learning objectives present and future.

8. Statement of interim and final performance requirements and measures.

The design characteristics of the programmed system fall into three major classifications, *organization, communication and control,* and *evaluation.*

Organization would deal with the underlying philosophy directing the system such as the analysis and planning for individual and group learning needs; and, the selection of methods to design materials to meet these defined needs. We would concern ourselves first with what is needed, second with which strategies of program construction should be used, and then consider how to complete the analysis and step sequences in the writing phases for either individual and/or group applications.

Communication and control is conceived of as primarily the teaching-learning process. Within this major classification is subsumed (1) highly individualized active student participation, (2) the methods and model of communication employed, and (3) those factors affecting the pace and efficiency of the learning process.

Evaluation of programmed materials would be guided by the performance criteria specified during the planning and analysis phases. We would be concerned with the meeting of these performance (learning achievement) criteria in terms of final or terminal student achievement and with program standardization during the validation phase. Within this framework we would consider (1) the underlying philosophy in the determination of performance measures, (2) the ways and means of specifying these measures, and (3) the meaning and use of terminal performance measures as final achievement tests.

The eight propositions or requirements provide a broad framework for an efficient system without restricting ways and means of implementation. Regarding the scope of such a system, I make four assumptions (Table IV): *First,* the application of the principles of programmed instruction is not restricted to self-paced or self-instructional materials, but can be extended to group instructional methods as long as the requirements are rigorously met. *Second,* automated teaching or the use of teaching machines is not necessarily a contingency of programmed instruction. The discipline of programmed instruction can be applied advantageously to any educational or training situation and does not necessitate the automated or teaching machine process. However, within certain situations which both permit and warrant it, the process of automated teaching can be achieved. Thus, the two terms, programmed instruction and automated teaching are not, as commonly mistaken, synonymous. Programmed instruction is the system, while the use of teaching machines for self or group paced applications must be examined in terms of unique contribution to the efficiency of learning, instruction, or both, for the specific application. A *third* assumption is that mass media of communication, per se, are not necessarily eliminated. When we use such media as closed or open circuit television, motion pictures, tapes, film strips, etc., we are transmitting information. If these media are modified to rigorously meet the stated system requirements, they can be used to teach each individual within the group on a highly individual basis. An important *fourth* assumption is that the proposed system does not limit methods or strategies of programming which now include linear, branching and mathetics. Each and all can be used advantageously and make unique contributions within the system. Neither environmental setting nor instructional application is limited, providing that all the requisite criteria are met.

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* Expressed broadly in a policy statement by USAF, Hq., Washington, D.C. The stated requirements as originally presented have been modified and expanded.

These stated postulates can be applied to our existing instructional environment to accomplish optimal design of instructional sequences. In fact, there are significant by-products to be derived from partial applications of the proprosed system. For example, immediate benefits can be derived by applying the stated organizational principles appropriate to programmed instructional methods for lesson planning procedures (Table V). Lesson planning, as employed now, organizes the teacher in terms of subject matter coverage and serves primarily as a guide. In contrast, I propose that the lesson plan should be considered as a student learning blueprint with the prime design measure expressed in terms of student achievement. To be truly meaningful, teaching objectives should be defined in terms of specific accomplishment, not subject matter coverage. Further, accomplishments should be defined in terms of student accomplishment, not teacher accomplishment. Applying the systems method, the teacher would establish specific student learning objectives, pre-state the methods and measures of student performance, and organize teaching steps to meet the learning objectives. You might comment that what I am suggesting is that the teacher is simply teaching the final examination. That is exactly right! With programmed instructional methods, however, the final examination does not represent a sampling of the concepts taught (as does conventional testing), but, rather, demonstrates performance by the students of all pre-established achievement measures covering the complete and total defined criteria of learning.

- * SELF PACED
- * GROUP PACED
  - A. CLASSROOM
  - B. MASS MEDIA
- * ALL PROGRAM STRATEGIES
- * TEACHING EQUIPMENT OPTIONAL

Table IV—Scope of Programmed Instruction System

Let us examine the proposed concept that teaching and learning be considered primarily as a communication and control process. In the conventional group setting, the teacher most often applies the lecture or "one-way" communication model. Students play a passive role. The teacher proceeds according to his best "guestimate" of how well the information is understood. But who knows what each student has learned? For group instruction to be truly effective, the lecture method must be replaced by the tutorial or "two-way" communication model. In this context, communication is defined as including three processes: (1) sending, (2) receiving, and (3) understanding. Without the assurance that there is "understanding" of that which has been "sent" and "received", we have not communicated.

CONVENTIONAL	*PROGRAMMED*
1. Teacher oriented	1. Student oriented
2. Subject coverage	2. Performance steps
3. Teacher guide	3. Learning blueprint
4. Instruction objectives	4. Learning objectives
5. Test samples	5. Test total measure

Table V—Comparison of Lesson Planning Methods

I am not proposing merely more question-answer interaction between teacher and student, but purposeful controlled questioning designed to test pre-set learning criteria measures. Lowry AFB evaluated the extensive use of classroom question-answer techniques allowing the students the freedom to stop the instructor during a presentation to ask questions. The results of this study (Table VI) indicated the following: 60% of the questions asked by students anticipated the instructor's presentation; 30% of the questions were completely irrelevant and seriously disrupted the instructional sequence; only 10% of the questions were meaningful and significant. In summary, 90% of student questions disrupted the flow and pace of instruction without contributing to the individual learning process.

Teaching groups using the tutorial model of communication with programmed instruction implies that the program proceeds in a group-paced manner.

The obvious questions to this proposal are: (1) how does this take care of the problems of individual differences, and (2) how does group instruction using programmed methods affect the individual's rate of learning.

Charles Frye, at Oregon College of Education, working under an N.D.E.A. grant, investigated ways to

STUDENT QUESTIONS AT ANY TIME

QUESTIONS	*	60%	*	ANTICIPATING
	*	30%	*	IRRELEVANT
	*	10%	*	MEANINGFUL

90% Disrupt without contributing to individual learning

Table VI—Lowry Question Study

GROUP VS. INDIVIDUAL PACING IN PROGRAMMED INSTRUCTION

Median Time In Minutes To Complete

Pacing	*Homo-geneous*	*Hetero-geneous*	*Difference*
Group	255	325	70
Individual	221	240	19
	34	85*	

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* Statistically significant (P. 01)

Table VII—Oregon College of Education (Charles H. Frye)

adapt self-instructional techniques to a group setting (Table VII). (Frye 1958) Frye assigned individuals to groups according to similiarities for such characteristics as ability and experience in order to learn a linear program in mathematics. For group instruction, material was presented to experimental groups on slides in a group-paced manner. The groups proceeded at a rate established by the slowest learner. He compared group-paced versus self-paced methods for the same material. The results indicate that students of "like" or homogeneous ability perform as well working under group-paced versus self-paced methods for the same their own pace. Frye concludes that "only when there is a wide discrepancy in abilities within a group is there any likelihood that learning rate will be retarded by forcing the learners to progress at the rate of the group."

A form of communication model proposed for group instruction which meets all the stated system requirements for programmed instruction is the classroom student response communicator such as the "Monitor-Teletest Communication." This system provides the capability for a teacher to program materials in carefully designed teaching steps according to the specifications stated. As an integral part of the teaching, criteria questions are posed to the class. Each student responds privately, is given immediate knowledge of the correctness of his response and has the ability to select the correct answer, if in error, before the group proceeds to the next question. As the students respond, the teacher is given immediately the percentage of correct answers for the students' first response. In addition, a continuous record of each student's performance can be presented. The Monitor-Teletest Communications System has been tried extensively at San Jose College, University of Southern California, Alamitos School District, Garden Grove, California and at the USAF Academy. In the Air Force Academy program, two-way communication was extended to four classrooms over closed circuit television. Instructions for all classrooms was directed by one television instructor.

In every case, the results show strikingly superior gains in the efficiency of instruction and individual learning when compared with conventional group instructional methods. I would like to present, in digest form, the results of three research programs using the Monitor-Teletest System with group-paced programming methods in classroom instructions.

DIGEST I

PLACE: San Jose State College, San Jose, California
INVESTIGATOR: Arthur Vicory
PROJECT: The roll of student feedback (knowledge of results) in group-paced programming.
PROGRAM: "Developing of Number Systems" natural through complex numbers.
POPULATION: 87 college students
STANDARDIZATION: Step I: 15 individuals to 95% correct response on program
Step II: 3 students in group, high, medium, and low mathematics aptitude.
EXPERIMENTAL DESIGN: Three experimental; one treatment group.

Experimental:
45 minutes of Instruction

Groups:

1. *Student response with feedback*
    A. Monitor-Teletest System
2. *Student response—no feedback*
    A. Marked answers on IBM answer sheet.
3. *No student response*
    A. Conventional instruction

Treatment
250 Minutes of Instruction

1. This group did not represent an experimental condition, but rather a treatment group to be used in comparison of conventional and programmed instruction methods.

The treatment group was taught similar materials in a formal course in mathematics. Five days of instruction were required to cover materials presented with the 45 minute programmed sequences.

Criterion test: 43 questions measuring recall and problem solving given one week following instruction.

RESEARCH RESULTS:

1. Monitor-Teletest Group (with student response and immediate feedback) performed significantly better than experimental groups (a) responding without immediate feedback and (b) taught conventionally.
2. There was no significant difference between Group 2 (student responding but without immediate feedback) and Group 3 (conventional instruction).
3. Treatment group (taught in mathematics course) required 250 minutes of instruction to perform 8% higher than group with feedback and 45 minutes of programmed instruction.
    1. Passive student response without immediate knowledge of results on a private basis has no significant effect on learning. (Groups 2 and 3).
    2. Active student response with immediate knowledge of results reinforces learning and increases performance beyond limits of mathematics program, per se. (Group 1).

Table VIII—Conclusions (Vicory)

DIGEST II

PLACE: University of Southern California, Los Angeles.

INVESTIGATORS: William Deutsch and Harold Gluth.

PROJECT: Comparison of group-paced programmed instruction with student feedback and response versus conventional instruction (no programming, no student response).

PROGRAM: Principles and use of Projection Systems.

POPULATION: 65 college students.

EXPERIMENTAL DESIGN:

Two control groups: 1. Two-hour instruction period.
   A. One hour lecture, one-half hour demonstration, one-half hour laboratory.
2. No student responding or immediate feedback.

Experimental Group	*Experimental Controls*
1. One hour group-paced program covering identical material.	1. Control instructors shown in advance programming objectives to insure same instructional goals both control and experimental group instruction.
2. Student responding with immediate feedback with classroom student-response communication system. (Monitor-Teletest).	2. Instructors qualified and experienced.

Criterion Test: Standardized 76 True-False examination given two days after instruction.

1. Experimental group using Monitor-Teletest System performed 25% higher in achievement tests than control groups.
2. No differences reported between control groups.
3. 50% savings in time of instruction (one hour) using group-paced programmed methods with student responding with feedback.

Table IX—Research Results (Deutsch)

DIGEST III

PLACE: Alamitos Intermediate School, Garden Grove, California.

INVESTIGATORS: Dan Kaufman, Betty Corrigan, and R. E. Corrigan.

PROJECT: A comparison of group tutorial instructional methods for science instruction with seventh grade students.

PROGRAM: Human Skeletal Systems.

POPULATION: 186 seventh grade students.

EXPERIMENTAL DESIGN:

Group Tutorial Methods Investigated

Method I	*Method II*
1. Group programmed instructional sequence on Human Skeletal Systems taught using overhead projector system, but without classroom student response system. (Teacher-paced. No direct student feedback.)	1. Identical group programmed instruction materials on Human Skeletal Systems taught using overhead projector system but with Monitor-Teletest System. (Teletest-paced. With individual student response and immediate feedback.)
2. Qualified science instructor. (One of team preparing programmed sequence.)	2. Qualified science instructor. (One of team preparing programmed sequence.)
3. Five days of instruction follwed by terminal achievement test.	3. Four days of instruction followed by terminal achievement test.
4. Retention test: 16 days later on identical examination.	4. Retention test: 16 days later on identical examination.

Criterion Test: 100 questions covering multiple choice (28), true-false (25), matching (25), and recall of technical data (22) designed in advance of instruction to test all pre-established terminal student performance (learning) objectives.

EXPERIMENTAL RESULTS

1. Group programmed materials increased the scope, depth, and complexity of instructional coverage by a factor of 5:1 as compared with this unit taught conventionally. Comparisons between instructional material specifications were made by the science instructors involved in the experiment.
2. Group programmed materials were taught in 5 days as compared with a 9 day instructional period previously required—a reduction of 60% in time of instruction for programmed methods.
3. The criterion examination for the programmed instructional sequence consisted of 100 questions. The prior examination for the conventionally taught unit consisted of 48 questions—an increased ratio of 2:1 for length of exam with the programmed sequence. The difficulty of the examination was reflected in the ratio of 5:1 increased coverage for the programmed sequence.
4. Qualifying students taught with instructional Method I (teacher-paced but without direct student-teacher interaction) achieved an 80% mean correct response on the initial test with a mean percentage correct of 73% on a retention test presented 16 days later interim period—Christmas Holidays). A relative loss of only 7% in student mean performance was experienced following retest.
5. Qualifying students taught with instructional Method II (the programmed sequence using the classroom student teacher response system Monitor-Teletest) achieved a mean of 84% correct responses on the initial test with a mean percentage correct of 78% on the retention test presented 16 days later (interim period—Christmas Holidays). A relative loss of only 6% in student mean performance was experienced following retest.

SUMMARY

1. Using group programmed materials (teacher-paced), the efficiency of instruction—as compared with a comparable unit taught conventionally—was raised by a factor of 10:1 as measured by scope, depth, complexity and time of instruction; and provided a 12% increase in mean achievement scores (80% versus 68%) with a mean error percentage loss in retention of 7% over a period of 16 days.
2. The combining of the Monitor-Teletest Communication system (Method II) with the programmed sequence provided a 22% increase in mean performance on the initial test and retention test as compared with teacher-paced instruction (Method I) using group programmed instruction.

With the Monitor-Teletest Communication system, group instruction becomes a highly individualized learning experience for the student and the teacher.

San Jose State College

	Possible Score = 100 (During Prog.)	% Correct Criteria Questions	
Group 1 (Student feedback) N = 24			
Mean	85.83	66.11	Students Respond
S.D.^{2}	52.71	26.21	
Group 2 (No student feedback) N = 22			*Programming*
Mean	80.64	62.27	
S.D.^{2}	64.01	42.16	
Group 3 (No student responding) N = 20			
Mean		61.21	Conventional
S.D.^{2}		64.80	Lecture
Group 4 (No student responding) N = 21			*Methods*
Mean	(Treatment Group)	72.57	Group 3—45 minutes Group 4—One week in course (250 minutes).
S.D.^{2}		115.56	

Table VIII—Research Results—Monitor-Teletest

The United States Air Force Academy has developed a complete instructional system combining the elements of self-paced and group-paced programmed instruction. Group-paced instruction is accomplished by combining the Monitor-Teletest System with closed circuit television (mass communication). A two-way communication network is provided between students in four classrooms and the television teacher in the studio. The system gives the teacher immediate knowledge of the level of understanding indicated by students and the rate at which problem solving is accomplished. With this knowledge, the teacher controls the level of complexity of instruction and the pace consistent with student needs. Students in turn are provided immediate feedback and reinforcement. As used in this application, the Monitor-Teletest System becomes a teacher-paced system. Following the televised instruction, students work on self-paced materials followed by practical problem solving tasks applying concepts learned. This systems model of programmed instruction should be significantly interesting to educators. The results have been of great significance to the Academy.

University of Southern California

* STUDENTS RESPONDING WITH FEEDBACK

25% increased test achievement over both control groups (P .01)

* 50% SAVINGS IN INSTRUCTION TIME

Using group-paced programming with Monitor-Teletest System

* NO DIFFERENCES BETWEEN CONTROLS

Table IX—Research Results—Monitor-Teletest

One of the questions posed by educators is: What is the role of the self-instructional program(s) in broad curriculum directives? Combining self-instructional materials in the school system has taken other forms than applying individual instruction in place of group methods. Two studies in particular, Teaching Machines, Inc. and AIR, indicate the significant advance in individual learning and achievement when self-paced programs are used in homework assignments. Significant contributions are reported in overall individual learning efficiency and student motivation when self-instructional programs are integrated into the instructional system in this and other manners.

The Relevancy of Programmed Instruction as a Systems Approach to Education

In March, 1963, a two-week meeting sponsored by the United Nations was held at the UNESCO house*, Paris, France attended by educational representatives from the majority of major participating countries in the world. The subject of these meetings was: "New Methods and Techniques In Education." The scope of discussions included a wide range of problems relating to support, research and development, and implementation of educational systems and applications.

With reference to methods and media planning, specific attention was directed to (a) radio and television, (b) electronic computers, and (c) programmed instruction methods and applications. The key to system implementation was integration of methods and media for more efficient learning and teaching efficiency.

Information presented in this appendix represents verbatim statements included in the UNESCO Report.

Several points, among others, were presented expressing group concurrence concerning the nature of methods and media. These are:

A. Programmed instruction is to be considered as a significant method calculated to enhance the value of instructional media.

B. The teacher remained the focal point for educational work.

C. Stress was laid on the need for "combining the best elements" of traditional teaching with judicious use of the new techniques.

D. Techniques (media) were becoming increasingly adaptable to integration in various educational systems.

E. Electronic computers might constitute an instrument for the efficient management of education (the establishr[illegible] the optimum use of time, premises, and sta[illegible]surement of pupil progress; and, in general, a [illegible]ic view of educational phenomena).

The expert group further concurred on the following points defined as educational needs and psychological aspects:

A. Educational needs, both in and out of school, were becoming steadily greater.

B. Teaching and learning efficiency is increased:

(1) by giving pupils fuller and more accurate information about the matter under study, with a resulting improvement in the quality of their knowledge;

(2) by enabling pupils, especially the better ones, to assimilate more, and more quickly;

(3) by making it possible to evaluate that assimilation more accurately and more objectively;

(4) by preparing the fundamental algorithms for the teaching of basic subjects.

C. Interaction methods should be used for the improvement and development of all educational materials (films, television programs, material for self-teaching purposes, and, indeed, all types of audio-visual aids or printed media). In particular, individual or collective "feedback" techniques should be used at every point for testing and revision, in accordance with the usual self-instruction procedures.

The group further concurred on the implications of these new media and methods for educational systems.

A. The use of such new techniques, especially television and programmed instruction, tended to affect the size of the groups being taught and the rate at which individual students or groups learned, and to add to the number of methods of presentation.

B. The systematic use of such methods and media gives rise to new problems of organization, teacher training, specialization of technical staff, production, distribution, and publications.

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* Report of a meeting of experts: New Methods and Techniques in Education UNESCO/ED/190, Paris, France

C. Such proposed changes are bound to lead to profound changes in school organizations, rearrangement of premises, coordination of teacher tasks and the rearrangement of educational practices (individual exercises, small group discussions, collective presentation to large groups, either lineally or with feedback).

D. The fundamental responsibilities of the teacher's function will not be modified, or diminish the vital importance of human realtions in teaching.

E. To develop improved methods of assessing the comparative costs of parameters which can be adjusted to differences in cultures, their requirements and their local resources.

Based on these stated conclusions, the international educational expert group recommends through UNESCO that, among others, the following recommendations serve as a basis of action for instructional system planning.

A. Particular attention is recommended to the development and use of imaginative ways of combining, for maximum educational gain at minimum costs, the resources of mass media, or self-instructional programming methods, and of teacher teams (instructional systems planning).

B. Special emphasis should be placed on adapting, to all media, the techniques of feedback from individual students of audience groups of mass media. Such feedback to the producer should consider factors of acceptance and attitude as well as instructional efficiency (group classroom and television student two-way response systems).

C. Research of a fundamental nature is needed to improve basic understanding of the learning process (programmed instruction application).

D. Special emphasis should be placed on developing the potential of individual programmed instruction methods (self-instruction and group-instruction).

E. An intensive effort should be devoted to obtaining and collecting data on comparative monetary costs and expenditures required for alternative means that seem to be capable of attaining a particular kind of needed educational outcome. Factors taken into consideration in collecting such data should, however, not only be the monetary outlay, but also the effect on manpower, on the required time, and on the improvement of quality of instruction (advanced derivation of parametric operating data for instructional systems planning).

The conclusions and recommendations of this international group of educational experts points out in clear language the required ways and means for future planning. The emphasis on instructional system planning combining programmed self-instructional and group tutorial applications strongly supports the significance of this proposed systems approach to education.

PROGRAMMED INSTRUCTION AND THE TECHNOLOGY OF TRAINING

Robert G. Smith, Jr.

Robert Smith presents a concept of a technology which concerns the use of seven steps to be followed in the development or revision of training programs: 1) Analysis of both operational and training systems, 2) Analysis of job, 3) Analysis of tasks, 4) Determination of training objectives, 5) Construction of training programs, 6) Development of proficiency measures, 7) Evaluation of training program.

In the nearly twelve years of HumRRO's existence, it has done research which has made a significant impact on Army training procedures.

In one of our earliest studies, for example, we have revolutionized training in Rifle Marksmanship, so that today's soldier learns to shoot in a realistic, combat-like situation, rather than in an artificial situation involving white cards with black dots on them.

We have been able to reduce training time in electronics maintenance specialties by as much as one-half, without loss of proficiency.

The successes we have had in reducing training time and increasing proficiency are due to the development of a concept of the Technology of Training. By this we mean a group of seven steps, which if taken in sequence, repeatedly create improvement in training.

These steps are: (1) Analysis of the operational system and the training system; (2) Analysis of the job; (3) Analysis of the Tasks to specify required knowledges and skills; (4) Determination of training objectives; (5) Construction of the training program; (6) Development of measures of proficiency; and (7) Evaluation of the training program.

You are probably saying to yourself—This looks all right as a model for conventional instruction, but what does this have to do with programmed instruction?

My theme is that it has everything to do with programmed instruction. Following these steps is the best way to avoid those failures of programming which appear in the literature these days. By failure, I mean cases in which programmed instruction does only as well, or not as well, as conventional instruction.

The first four steps are devoted to making a precise determination of what is to be taught. Historically, HumRRO has made its greatest successes in this area. By studying the system in which the soldier is to work, by analyzing the job, eliminating the nice to know, and teaching what the soldier must know, we have consistently obtained significant results.

These findings are strongly supported by Gagne (1962a), in his presidential address to the Division of Military Psychology of the American Psychological Association. Gagne said: "Here are the psychological principles that seem to me to be useful in training: (1) Any human task may be analyzed into a set of component tasks which are quite distinct from each other in terms of the experimental operations needed to produce them; (2) These task components are mediators of the final task performance; that is, their presence insures positive transfer to a final performance, and their absence reduces such transfer to near zero; and (3) The basic principles of training design consist of: (a) identifying the component tasks of a final performance; (b) insuring that each of these component tasks is fully achieved; and (c) arranging the total learning situation in a sequence which will insure optimal mediational effects from one component to another."

Gagne (1962b) further states that the traditional principles of learning, such as reinforcement, differentiation of task elements, familiarity, and distribution of practice are much less important in training than the principles of task analysis, intra-task transfer, component task achievement, and sequencing.

Now let me discuss the seven steps and their relevance to programming. First we, analyze both the operational system and the training system. A system is a group of inter-related and inter-communicating components, organized to achieve a goal. Some of the components may be machines, others will be people. Systems also contain rules or policies which affect their operation. They are also embeded in larger systems, which place constraints upon the smaller systems.

The student is a part of a training system. When he graduates he will become part of an operational system.

By analyzing the operational system we discover the context of the job he is to perform. We learn of policies which restrict him to the use of certain kinds of tasks, and eliminate the performance of other tasks, which we might think it nice to teach him. We learn of his role in contributing to the mission of the system. We learn which of his tasks are vital to the mission of the system, and which are less essential. This helps us determine the level of proficiency we will require him to reach.

By analyzing the training system we discover what we should expect the student to bring to our particular course, and the possibility of later skill development,

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perhaps on-the-job training in another course. We learn of policies which, rightly or wrongly, may place constraints on the kinds of training we may give him.

Step 2 is an analysis of the job. Many training people tend to think that there is just one kind of job analysis. Actually there are several kinds, and for several different purposes. The kind of job analysis performed for setting up personnel classification systems, or job evaluation, just won't do for training. They are too general.

A job analysis for training must identify all the major duties in the job and the tasks which make up these duties. The physical and environmental conditions of the work must be described. We must specify the tools, the test equipment, the job aids and manuals the worker must use. Finally we must determine the standards he must meet, in terms of accuracy and time.

At this stage we have a list of the duties and tasks which must be performed. We must now proceed to step 3, the specification of knowledges and skills.

The initial step is to analyze each task to be performed in stimulus-response detail. We must know what must be done, how fast, and how accurately. We must identify the signals or cues which tell when an action is to be performed. We must describe the action precisely, and we must describe the feedback which tells whether the action has been performed correctly.

One of the reasons for making a precise description of a task is to identify the kind of symbolic material needed to perform the task. The symbols are usually called knowledge. The precise determination of knowledge is extremely important. One of the most common failings, and greatest wastes in training, is to teach more knowledge than we have to. There are large bodies of knowledge, theory and history surrounding nearly every human endeavor. But what may be necessary for the scientist or engineer in a given field may be not at all required by the technician.

Certainly there will be specific knowledges required in any job. Among these will be: (1) nomenclature; (2) location of work or components; (3) identification of tools, etc.; and (4) specific work rules and procedures.

In some instances a general principle enables a man to respond to situations he has never precisely encountered before, or at least to reduce his trial and error in making the correct responses. But these principles are ivory-tower unless they are anchored in the real word.

Let me give an example: We have a bit of knowledge, in the form of an idea, statement, or self instruction. This might be, "Never ground a hot electrical conductor".

First, we need the perception of things in the real world which require this knowledge. For example, the trainee must perceive bare wires, terminals, junctions, prongs, and other objects as potential hot electric conductors. He must learn to perceive what a grounding condition is, but he must learn these perceptions as part of the knowledge.

The student must also learn the real world responses indicated by the knowledge. He can put the knowledge to work by not standing in water, or by using a rubber or bakelite shield, insulated tools, or rubber gloves, or by avoiding physical contact with the object he perceives as a hot electric conductor.

Unless a principle has been anchored on both the perceptual side and the response side in the actual work situation, we can never be sure that the knowledge is really necessary.

This is important. Unless we follow it, we will be teaching whole courses in mathematics when the job requires only the ability to make a few simple computations. Or, we will be teaching the theory of equipment operation instead of the job the worker has to do with the equipment.

The importance of this idea is reinforced by the work of Shriver (1960) (Shriver, Fink and Trexler, 1961) in HumRRO research Task FORECAST. In the field of electronics trouble shooting, it has been traditional to teach the theory of electronics. This includes a body of general theory, as well as the theory of operation of particular circuits in particular equipment. From this knowledge the repairman is supposed to determine where the malfunctioning component is located. In a system which may contain over 100,000 components, this is no mean trick. Using his theoretical training, the repairmen is expected to determine where to make checks so as to narrow his search, and he is expected to compute the electronic values he is expected to find at that point.

Studies of the behavior of repairmen show that this system doesn't work in practice. They make more checks than they need to. They check in the wrong places. Frequently they do not use test equipment properly.

The conventional theory taught is that required to design the equipment. The significance of Shriver's work is that he developed a new theory of electronics systems, a theory designed from the maintenance point of view. This theory involves a restructuring of the system into trouble-shooting blocks, which are different from usual electronic chassis packaging. In addition, a simply learned trouble shooting strategy was taught. This strategy was: (1) from symptom to symptom area; (2) from symptom area to trouble-shooting block; (3) from block to tube chain; and (4) from tube chain to individual part.

What was the result? The result was repairmen trained in 400 hours who were as proficient as repairmen trained in the conventional course of 1000 hours. And in another study, a small amount of additional practice resulted in a significant increase in proficiency.

Step 4 is the Determination of Training Objectives. There are two matters of significance here. First, we must select what we are to teach in our particular course or program. An objective is the statement of the behavior we expect the student to display at the end of our program. This is often short of the proficiency ultimately desired on the job, depending on time, facilities, cost, and the opportunity for later on-the-job training.

Several factors should be considered when we select what to teach, and the level of proficiency desired as a result of our program:

1. What does the student know already? We seldom take a close look at what the student brings to our course. Yet there may be significant amounts of what is required on the job already known by the student. This is especially true when, for example, already trained technicians are retrained in new equipment.

2. What will the student learn in later courses, or on the job? We should not permit unplanned redundancy or duplication to exist.

3. What job aids are available on the job? Many aspects of job performance are supported by check lists, manuals, tables of data, slide rules, etc. The availability of job aids should be considered when deciding on objectives. If a man will look up data in a manual, he doesn't need to learn how to derive this data. Or, if he will use a check list, there is no need to require him to memorize the sequence of actions in a procedure.

4. What must the student be able to do immediately on the job, vs. the things he can develop on the job?

5. What behaviors are critical to the performance of the operational system? There are many tasks or parts of tasks which are not very critical. There may be a supervisor who can remind the worker if he fails to perform correctly. Yet there are other tasks on which failure may mean disaster, either to the worker or the system.

Having determined what to teach, we must describe our objectives in behavioral terms in sufficient clarity to communicate to our students and others in unambiguous terms. I know of no better treatment of the problem of describing objectives clearly than Mager's (1961b), clever and amusing scrambled book, *Preparing Objectives for Programmed Instruction.*

I have devoted a considerable part of presentation to the matter of determining precisely what to teach. Why all this concern over precise, job related objectives? The reason is simply that it is quite costly to teach the wrong things, either conventionally or via programmed instruction. Let's examine some of these costs.

First, the costs of teaching too little are fairly obvious: (1) Additional training on the job will be required. There are variations in job situations, but often the job is arranged for work, rather than for training. There may be less time and poorer facilities for teaching on the job than in school. In addition, there may be complaints from the users of your graduates which can be embarrassing; and (2) Personnel may be endangered, or equipment damaged. Production my be slowed.

A much more subtle cost is teaching too much. This is more subtle because you will not hear complaints from the users of your graduates. Yet the costs are there just the same: (1) Teaching more than is needed to do the job will require longer courses, more instructors, and more programs than are necessary; (2) Students may fail on the irrelevant parts of the course, even though they may be capable of performing well on the job; and (3) Irrelevant criteria may be used to select students to attend the course. Irrelevant prerequisites may be established. Then students who could learn the job don't get a chance to do so.

It is for these reasons that I have come to believe that the problems of deriving clear, job related objectives are the most important in training.

Step 5 is the Construction of a Training Program. For Programming, this is the equivalent of frame writing. I am not going to talk about the art of writing frames. This has been described too often to be repeated here. Instead, I would like to mention some research findings which I feel would, if put to use in a programming context, make significant contributions to success.

Several years ago, HumRRO conducted a study under the code name RADAR VI (Hitchcock, Mager and Whipple, 1958). This study resulted in a reduction of training time from 33 to 26 weeks for electronic maintenance technicians. At the same time, the graduates of this course were as proficient as men who had 18 months of field experience, a significant improvement over the control course. One of the things which was done in RADAR VI was to give copies of the course objectives to the students. So the student's time could be spent in meeting the objectives rather than in crystal-balling, or in military slang "G-Zing", what the instructor wanted. This can save a tremendous amount of time.

Those of us who have taught can remember the questions the students ask us to try to discover our objectives. "Will this be on the exam? Do you give multiple choice or essay tests? Do we have to know how to derive this formula or just how to use it?" These are some typical questions.

Those who have been students recently can remember the time we spent talking to former students of our courses to find out what the professor really wanted. Among graduate students coming up for qualifying examinations this can reach a high art.

Why don't we give the students our objectives? Whether the course is programmed or not, this can be quite effective. It will remind the student of our goals when he gets bogged down in the detailed frames of a program, wondering where it all leads to.

When you are pre-testing, or de-bugging your program, giving the student the objectives for your program can be useful. The student can then raise questions about the relevance of portions of your program to your objectives. Our currrent procedures for pretesting programs are biased in favor of detecting places where we have gone too fast for the student. The revisions we make tend to add frames and lengthen the program. We need corrective measures to eliminate some of our pet topics which may not be relevant to our objectives. It seems to me that giving the try-out student the objectives of the program may provide this necessary counter-balance.

One of the problems faced by the programmer is that of sequencing. In a long program, dealing with many topics, arranging those topics in an effective sequence will be one of the programmer's toughest problems.

HumRRO research has provided a sequencing principle which should be useful in making the broad decisions about sequencing topics. This has been termed the Functional Context Principle (Brown, Zaynor, Bernstein, and Shoemaker, 1959). One of the more interesting aspects of this principle is that it seems to work especially well for students of lower aptitude (Goffard, Heimstra, Beecroft and Openshaw, 1960).

In Functional Context sequencing, we always maintain a job-related context for the material we present. Translating this into educational terms, we might begin by describing how certain knowledges might be used in real life. We might begin with an overview of the job itself. In RADAR VI we taught maintenance men how to operate the equipment at the very first part of the course. By this means, the students learned the purpose of the equipment, how it looked and felt. There are many ways by which we can give a man a general view of his job.

In detail, the Functional Context approach has the following features: (1) Instruction is aimed at producing effective maintenance men, without regard to competence in electronic theory. The theoretical material presented was only that which had clear cut application to the repairman's job; (2) All skills and knowledges were taught in a whole-to-part or trouble-shooting sequence. Thus, early in the course, system trouble shooting was taught, followed by work on smaller stages and, finally, the isolation of components; and (3) Each lesson is designed to provide a framework, or context, for the next one.

Thus, from the overview of the job we become more and more specific. Each step we take is related to the job context previously established. The student learns new skills or knowledges only when they are required by the job.

The sequence then moves from the whole to the part. In electronics maintenance, at least, this has the interesting result that basic electronics, which deals with components, gets taught last, rather than first.

We are all used to being taught in the seemingly logical way of learning "fundamentals" in the absence of any tie to the purpose of learning these things. But this is not a very efficient way.

By using the Functional Context principle in laying out the general sequence of our programs we should be more successful in making them more meaningful and interesting to the student.

But what about more detailed sequencing problems? You will remember that I stressed earlier the position of Gagne that we need to analyze tasks into components which mediate transfer to final task performance. Gagne(1962b) has recently made suggestions for making this analysis. Starting with a final task, he asks, "What would the individual have to be able to do in order that he can attain successful performance on this task, provided he is given only instructions? This question is then asked of the subordinate tasks or classes of tasks, until we can go no further.

Gagne has shown that students who have not mastered the subordinate tasks cannot achieve the higher order tasks. Further, the way to achieve mastery of the final task is not to practice the final task alone but to learn the subordinate tasks which lead up to the final task.

The combination of these ideas, the Functional Context notion for the broad sequence, and Gagne's analysis for the more detailed sequencing, should make the programmer's sequencing decisions easier.

Step No. 6 is the Development of Measures of Proficiency. Proficiency tests are scorable samples of actual job performance. HumRRO has found performance tests more appropriate for determining training progress than written tests. We want men who can actually do the job, not just talk about it.

We have developed electronic trouble-shooting tests which require the actual location of faulty components in real equipment. We have required soldiers to navigate on land from one point to another, and not just answer questions about using the map and compass.

When preparing a program designed to teach an actual job task, it will be necessary to develop a performance test to be sure our programs have actually taught this task.

Step No. 7, our last one, is the Evaluation of the Training Program. Proficiency tests must be routinely used in order to insure control over quality of the training program. The results of testing must be fed back to the instructor or programmer so that he can make appropriate changes in the program. The tests should also be used to determine the effect of the changes made.

Just what is the significance of the seven steps just described for programming?

We have all been impressed by the cases which showed that programs resulted in learning with savings of time of 25-50% over conventional instruction. I would like to point out that HumRRO, by following the Technology of Training has achieved comparable savings without the use of programs. How much more effective would programs be which were based on these concepts?

Another reason for stressing the Technology as applied to programming is to reduce the risk of a programming failure. Raab(1961) provides a case in point. Raab evaluated a set of mathematics programs prepared for junior high school students. These programs did not teach as well as conventional instruction and took longer. The students complained that they were bored and did not know where they were headed. A review of Raab's report from the standpoint of the Technology is enlightening: (1) The program included material the students had learned before; (2) No objectives were provided for the student; (3) The tests used to evaluate the programs were not selected or prepared on the basis of the program; and (4) The programs did not provide a basis of meaningful context for the student.

In summary, let me say that the notions of the Technology of Training provide powerful concepts for any kind of training, programmed or not.

SETTING PROGRAMMED INSTRUCTION OBJECTIVES USING SYSTEMS METHODOLOGY

Charles S. Morrill

Charles S. Morrill has presented a clear seven step procedure for setting objectives into a systems framework using systems methodology. The advantage of using systems methodology in setting objectives for programmed instruction is to increase the probability that the resulting programs will be an integral part of the training system. Some less obvious advantages may prove equally interesting to many readers.

Clearly, one of the major objections in using the word "systems" in the title of this paper is that much controversy exists concerning an appropriate definition for this word. The fundamental principle, for example, of systems design, has been stated as follows:

"Maximize, in some sense, the expected value." (Goode & Machol, 1957)

Recently Bamford (1962) has written a short treatise entitled *On the Meaning of "System"*. In this paper he attempts to define formally the concept of a system by interpreting and formalizing some properties ascribed to systems and to construct a language for the disciplined discussion of systems. Others (Ellis & Ludwig, 1962) have tried to define systems in terms of precise mathematics. In order to study and define the functions of a specific system, Gordon (1962) states that, "First, a model of the system to be studied must be constructed, and then a program that embodies the logic and action of the model must be written". He goes on to say that, "The model is a set of equations and logical statements that expresses the relationship between the components of the system and the various parameters associated with the system".

While it is true that dissension is rampant concerning the concept of a "System", there is a core element within this dissention which is applicable to using systems methodology in setting objectives for programmed instruction. The objective, then, of this paper is to explain one approach to accomplish this end.

In reviewing the work done in personnel selection, Dudek (1963) has stated that, "Several papers brought out the fact that the study of personnel selection and classification in relation to such things as assignment, placement, manpower utilization, training, group structure, man-machine systems, and organizational management is more meaningful and profitable than the study of personnel selection *in vacuo*". Although Dudek's emphasis is in the area of personnel selection and classification, he very well makes the point that training is a *part* of a system. The concept of a training system includes all of the facets which are mentioned above. In discussing selection problems, Haire (1959) emphasized the need for adequate criteria, and similarly noted that ". . . the assessment of training continues to be much discussed but is dealt with only to a limited extent". Haire's position is that coordination between related areas where identification and development of adequate criteria are concerned is essential.

Let us assume, for the moment, that programmed instruction is a method of teaching and training which is part of an overall training system. Our first step, then, in developing a program is to prepare objectives for that particular program. Mager's recent book (1961b) in this specific area outlines these procedures most effectively. And it is true that if Mager's procedures are followed, the objectives thus derived will be clear, specific, and measurable. However, it is necessary to look beyond the particular objectives for the program to insure that these objectives are appropriate to accomplish the overall training or educational goals. Permit me to outline seven steps for setting objectives using systems methodology: (1) Examine overall objectives of the educational or training system (as defined before) in which the programmed material will be used; (2) Determine which overall objectives of the system would be most efficiently and effectively achieved using programmed instruction; (3) Develop the objectives for the programmed material and check to determine if they are in any way in conflict with the overall objectives of the system. If no conflict, fine. If conflict exists, ask such questions as:

a) Are the program objectives achievable in view of the constraints imposed on the overall system, e.g. money, time?

b) Are any specific program objectives directly in conflict with those of the system?

c) Do the program objectives help to fulfill the objectives established for the system?

This procedure checks the program objectives early enough in the development procedure to prevent a proliferation of inconsistencies; (4) Look at the entire system to determine if other methods of instruction (either being used, or which could be developed) would fulfill the objectives for the programmed material and the training objectives of the system more effectively and efficiently; (5) Given that the program objectives are appropriate, examine the system and the environment in which it operates to see if there are any indications that there is a best method of *PRESENTATION* for the programmed material. For example, are there any constraints, e.g., money, space, which would obviate the use of certain kinds of teaching machines? Is there a machine already chosen for which the programmed material must be written?; (6) Survey the field of available programmed material to determine if material already available or in the process of being developed might well fulfill the stated objectives. Clearly, in some areas which are specifically related to a particular company operation, programs will not be available; and (7) If programmed material is available, determine the quality of the material, and how it will satisfy the objectives which have been established. Although already developed materials may not fulfill all the established objectives, it may be worthwhile to modify either the objectives or, if possible, the program, rather than develop new programmed material.

While it may be true that the above seven steps will not guarantee that programmed material will be an integral part of a training system, the probability is greater, it seems to me, that the resulting materials will prove more useful as part of an educational or training system than if the steps are not followed. The essential point, however, is a simple one. Programmed material either developed in isolation or thought of as a unit of material unto itself with "no strings attached" will probably be less effective than materials developed in a systems framework using systems methodology.

The use of systems methodology in establishing objectives helps bring together several talented people, many of whom will represent different technologies. The fact that these interested and qualified people are uniting their efforts to determine objectives in and by itself will help to renew the vigor and raise the standard for development of both specific programs and training and educational systems. Secondly, a review of the entire system in terms of objectives may very well highlight previous errors in both materials and stated goals. Training and educational systems are dynamic. Thus a review occasioned by the addition of programs to an already existing system may have a catalytic effect on the entire system. Thirdly, additional cost which must be incurred to program material, which may already be part of a curriculum, provides a stimulus for close scrutiny of the entire teaching or training system. Often the mere introduction of programs will force changes in overall system objectives and/or procedures. The last obvious advantage is that an analysis of program objectives in terms of total system objectives forces an evaluation of both. It is important indeed to stimulate interest in the evaluation of system objectives as a focal point for the design of subsystems based on programmed materials.

THE IMPLEMENTATION OF A SYSTEMS APPROACH TO PROGRAMMED INSTRUCTION FOR A STATE DEPARTMENT OF EDUCATION

William F. Ryan

William F. Ryan concurs that our greatest barrier in moving into a new plan for improving State education departments will be our loyalty to the inadequate organizations and arrangements which exist today. If we can recognize them as being the best we could imagine when we invented them, give them full credit for what they have accomplished, and then move on to something better, States can maintain leadership in education.

The organization for education on the state level is little different structurally from other organizations such as any business, industry or the military. All across America experiments with new concepts and practices are beginning to show significant results in the improvement of quality. Many states have taken the lead in this movement at both the state and local levels. These efforts, however, are not enough. They need to consider how best to bring to bear the total educational resources of the state in a massive attack on resistance to constructive change. Recommendations for statewide action have been undertaken to evaluate new practices and devices, to initiate and expand constructive experimentation in our schools and to facilitate and accelerate widespread use of practices and devices which have proven successful in their schools. Specifically, the high administrators have listed in their programs of study educational television, team teaching, large and small group instruction, ungraded classes and teaching machines and programmed learning.

The State of New York, for example, with reference to the Brikell report, approached the systems concept toward newer instructional media with certain natural self-imposed limitations.

First, they did not investigate classroom practice due to the extremely wide variance of behavior of individual teachers with their classes. Second, they did not assess educational institutions of higher learning from any aspects other than their impact on instructional innovation in local public school systems.

How does one go about conducting a study? The following methods have been used to conduct a study on innovations in state school systems: schools were selected to find out how they made decisions about instructional change, not to observe or to assess their new programs. One state had a project which for several years involved collecting elaborate data from a sampling of over 300 different school systems which represented the total range of types and sizes of the state.

Active, well-financed suburban school systems were chosen somewhat more often than other types because it seemed important to study closely those conditions which are most conducive to rapid educational change, according to previous research into community types. The fact that such school systems were generously represented in the survey gives a special urgency to the conclusions in this report. If the conditions which affect change even in well-supported, suburban schools are as described here, then in other school systems not so richly endowed with resources, the pace of change is presumably even slower, the direction even less certain.

The State of New York was used for a pilot survey by the Center for Programmed Instruction and the U. S. Office of Education in determining the variance of usage, attitudes and program reorganization change from 1962-63 to 1963-64 programs. The study included the following components: (It should be noted that the word "program" refers to "programmed learning materials.")

1. Parents and citizens groups in most communities do not exert a direct influence on the adoption of new types of instructional programs, but their influence is decisive when exerted. In disseminating new programs, it is not necessary to arouse the active enthusiasm of local parents, but it is necessary to avoid their active opposition.

2. The board of education in most communities is not a strong agent in determining the oath of educational innovaton, but its influences are decisive when exerted. New programs must be disseminated in a manner which will not arouse the opposition of boards of education.

3. New types of instructional programs are introduced by administrators. Contrary to general opinion, teachers are not change agents for instructional innovations of major scope. To disseminate new types of instructional programs, it will be necessary to convince administrators of their value.

4. Classroom teachers can make only three types of instructional change in the absence of adminstrative initiative:

a. Change in classroom practice.

b. Relocation of existing curriculum content.

c. Introduction of single special courses at the high school level.

Classroom teachers cannot be expected to introduce new types of instructional programs without administrative attention and in-service courses designed for individual teachers rather than for entire departments or faculties (that is, courses designed to improve the teacher rather than to change the program) should be limited to matters which can be accomplished in one of the three ways indicated above.

A teacher who returns to his school with new information and new teaching skills is most likely to use them if he can employ them in his own classroom without distrubing the work of other teachers. If his new information and skills demand the creation of a new course for their realization, he is most likely to get administrative permission for a course at the end of a sequence which will cause least disturbance to the work of other teachers.

1. Professional suspicion about the value of innovations in other school systems, and even about the sincerity of other innovators, is a widespread and serious inhibitor of educational change. Recommended new programs must be disseminated in a way which will allow the practitioner to quell his own suspicions.

2. The most persuasive experience school personnel can have is to visit locations where successful new programs are in action. Speeches, literature, research reports and conversations with participants outside the actual instructional setting are interesting but relatively unconvincing. Recommended new programs *must be demonstrated* so that they can be observed in action.

3. Anything abnormal, unreal, or artificial in the circumstances surrounding an observed program, that is to say, anything appreciably different from conditions in the visitor's own school system, can rob a visit of persuasive effect. Recommended new programs must be demonstrated in schools quite similar to those from which visitors come.

4. New instructional programs can be successfully introduced despite initial apathy or even opposition on the part of a number of teachers.

5. The most successful innovations are those which are accompanied by the most elaborate help to teachers as they begin to provide the new instruction. Instructional innovation should be accompanied by substantial, continuing assistance to teachers.

6. Instructional innovations are many times evaluated by observing the reactions of the students. In the eyes of the practitioner, no other evidence out-weighs student reaction as a measure of success. More complex evaluative techniques are rarely used. Observers who visit demonstrations of recommended new programs should be given an opportunity to talk with students about their reactions to the new instruction.

7. Instructional innovations usually seem to the people using them to be distinctly better than what they were doing before. The reactions of users cannot be relied upon as the sole method of evaluating novel approaches. The attention, encouragement and recognition given to teachers by people outside the classroom during the introduction of new programs are among the strongest causes of their success. In evaluating new programs, attention, encouragement and recognition should be supplied equally to both the experimental and the comparison settings.

A state education department exerts a powerful influence on educational change in local schools. In some ways the department is an active stimulus; in other ways it is a serious barrier. It soon became obvious during the survey that the elementary and secondary schools look to their state departments for leadership and feel much more comfortable in making instructional innovations when the department has endorsed them. Thus the posture of the department toward innovation in general and toward innovation in particular is of great import.

Following recommendations for a coordinated statewide effort in the State of New York, we propose that state education departments do the following:

1. Create a semi-autonomous agency to stimulate and to finance the design and rigorous evaluation of new instructional programs for elementary and secondary schools.

2. Create field locations all across the state to achieve the enriched settings needed for the design of new instructional programs. School and college people should be hired temporarily, brought together and freed to design a program.

3. Design programs to be put through an elaborate statewide field test to find what they will accomplish. Here again, the evaluators should be agency staff members of schools and colleges hired temporarily to do the job.

A state educational plan to introduce programming should have three functions: (1) to demonstrate proven and endorsed programs, (2) to teach teachers in the component districts how to carry out the new programs, and (3) to arrange for nearby colleges and universities to teach the necessary skills on a continuing basis. New programs should be demonstrated by regular teachers in regular schools. The necessary new skills should be taught by a staff of the talented school and college people hired temporarily for that purpose.

A number of existing organizations in State Departments are now performing operations which would be of far more significance to the schools if they were part of an overall plan for accelerating the pace and improving the direction of educational change.

The work of the state education department, the colleges and universities, the lay and professional associations, the philanthropic foundations, and the commercial organizations should be coordinated with the work of a state education department.

Some other existing organizations are performing operations which could be better performed under an entirely new arrangement.

BEHAVIORAL PLANNING NETWORKS

Gustave J. Rath

Gustave Rath presents a technique for interconnecting terminal behaviors to be taught in an auto-instructional program. Four quasi-mathematical rules are used to organize the behaviors into an efficient planning network of minimum size. The finished net can be used to guide programmers toward the most efficient sequence of frames. It also guides the program editor in making meaningful but integrated assignments to members of the programming team.

General agreement exists upon few things in the field of programmed instruction. However, everyone agrees that one of the main requirements, and most critical jobs, in the development of programmed materials is the establishment of proper objectives in the form of terminal behaviors. A behavioral planning network allows one to organize the terminal behaviors according to the real structure of the material. Thus, this network aids in the planning and execution of the program.

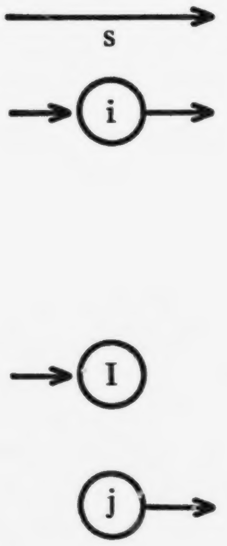
A behavioral planning network is a technique for describing the real structure of the knowledge taught by a self-instructional program. Auto-instructional programs or programmed instruction materials consist of sequences of material which modify the behavior of the learner in a more or less permanent fashion. The modification of the behavior is effected through the use of psychological techniques and art which have been extensively described in the literature.

Definitions

A programmed sequence consists of a series of psychologically and factually sound teaching events which are prepared through the use of adequate materials which take an organism described by an existing state of measurable behavior and bring it to a new state of measurable behavior. This new state might be achieved by the addition of a new behavior, the elimination of an old behavior, or the modification of an existing behavior. A programmed sequence is represented by an arrow as shown in Figure 1.

The number appearing under the arrow indicates the number of steps this program sequence is from the beginning of the network (described by the beginning terminal behavior).

A terminal behavior (TB) is represented by a circle with incoming arrows and departing arrows representing programmed sequences which precede the development of the terminal behavior and show the direction to the next step. The graphical representation of a TB is shown in Figure 1. Each terminal behavior must be named and described in measurable, operational terms. For the purposes of symbolism, they may be numbered, but each behavior must refer to a real measurable entity. A lower-case letter represents complete terminal behaviors.



a *Programmed Sequence*—S is the number of steps from the beginning terminal behavior

a *Terminal Behavior* = K is a part behavior such that

$$\sum_{K=1}^{K=N} i_K = i$$

a *Ending Terminal Behavior*—has no programmed sequences following it.

a *Beginning Terminal Behavior*—has no sequences leading to it.

Figure 1. Definitions

A beginning behavior is a terminal behavior which requires no antecedent programmed sequences for the population being trained. The specification and analysis of the population begins with the existing behaviors, and these are the beginning behaviors of the network. An ending terminal behavior, which is represented by an upper case letter in a circle, has no succeeding programmed sequences. The purpose of a program is to establish a set of specified behaviors in the student.

It is understood that a TB may consist of several part behaviors of the desired task, and in many cases different programmed sequences are necessary to separately elicit the part behaviors. In some cases, the synthesis of two part behaviors into a terminal behavior occurs simply by the sequential non-ordered application of two programmed sequences; that is, one may apply one and then the other with no regard to order. Having both sequences presented, the full behavior may then be elicitied. Part behavior is symbolized by letters, such i_K. A terminal behavior is made up of the aggregation of several part behaviors, $i = \sum_{K=1}^{K=N} i_K$, as seen in Figure 1. When simple aggregation cannot occur by juxtaposition, then intermediate aggregating sequences are necessary. Rules for sequencing are presented below:

Rules of Aggregation

Given a sequence, as illustrated in Figure 2, which has as its ending terminal behavior the beginning behavior of another sequence, the two may be aggregated or combined to form a larger sequence.

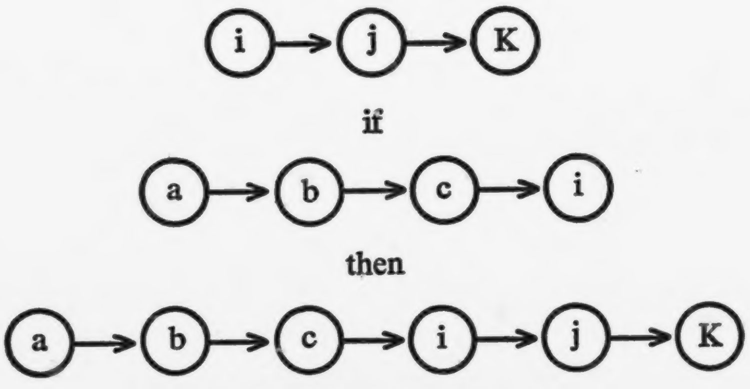


Figure 2. Rules of Aggregation

It is possible to have a network where some sequences will never be aggregated. For instance, a course directed toward teaching students how to drive a car may have a completely independent sequence on how to buy license plates. In many cases, procedural sequences are not organically related to the technical core and, therefore, do not have to be shown as related parts of one network.

Rules of Synthesis

Given two sequences which are unrelated, but which have sequences which terminate in related part terminal behaviors, one may synthesize the two sequences by forming a new terminal behavior which is a combination of the two existing part behaviors.

The rule of synthesis is illustrated in Figure 3. The synthesis presumes that the part behaviors be additive and do not require additional steps to achieve it. In those cases where additional steps are required, it is not a synthesis but an aggregation.

Rules of Minimal Antecedents

The rule of minimal antecedents is directed toward shortening the networks. If there exists a beginning behavior which may be followed by two or more terminal behaviors independently, these must be shown as emanating from it as their permanent beginning behavior. Minimum antecedents may be operationally defined by using the following formula. If one takes S_m, a sum of the number of steps on each programmed sequence from its beginning terminal event, one may use an index $D \sum_{M=1}^{M=N} S^2 m$. The sum of squares must be minimized to achieve the needed end. Figure 4 shows that the more sequences that can emanate from the beginning or early behaviors, the shorter the networks that will be developed. This is not to imply that a program will be written and presented as described by the network according to the curriculum described later. The description of the relationships of the terminal behavior in this manner is very important and useful.

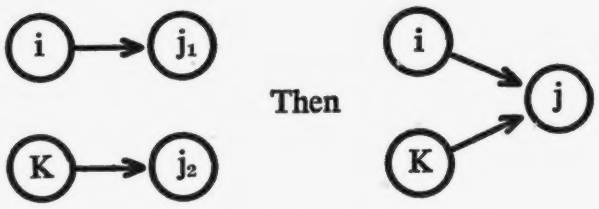
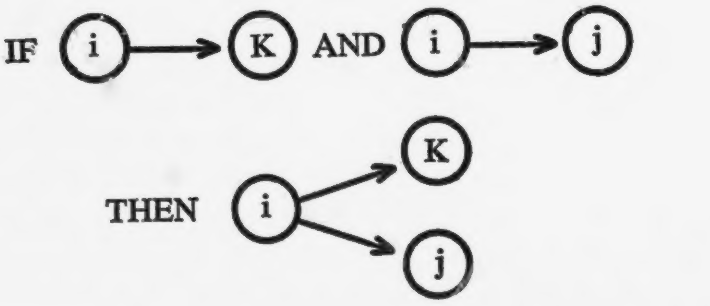


Figure 3. Rules of Synthesis



A PROGRAM SHOULD BE ARRANGED SO

THAT THE $D = \sum_{M=1}^{M=N} S^2$ IS MINIMUM IF

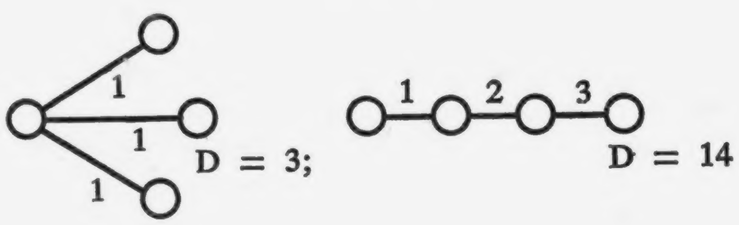


Figure 4. Rule of Minimum Antecedents

Rules of Partial Ordering

The rule of partial ordering is illustrated in Figure 5. If two sets exist which have at least one common aggregating element (TB), then they may be combined. They should always be combined or attached in a manner such that the rule of minimum antecedents is supported.

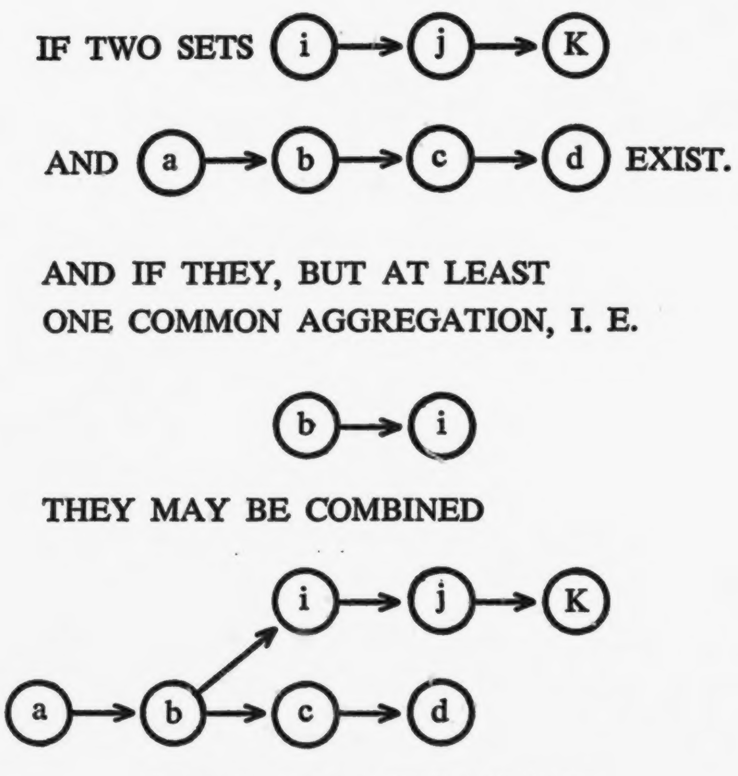


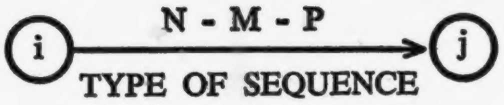
Figure 5. Rule of Partial Ordering

Estimating Program Size

A frame is a unit of programmed sequence which contains a) the confirming response and a new stimulus, b) the confirming response, or c) the stimulus. A classical linear response frame would fall in (a), a branching or intrinsic program will consist of several (b)'s for each (c).

In order to estimate the size of a program, one may write, for each programmed sequence, the number of frames expected for that sequence over the arrow (as shown in Figure 6). To improve the accuracy of prediction, one can also estimate the minimum and maximum number of frames.

If the program is not going to be homogeneously written, one may write the techniques which are planned under the programmed sequence. The hypothetical estimate of a program's size based on a behavioral network is shown in Figure 7. One accumulates to any point in the program for the entire program, the minimum expected, and maximum number of frames expected. Generally speaking, one should have a minimum of one TB for each 25 frames, or approximately a minimum of four TB's for each hour of running time.



N = MINIMUM NUMBER OF FRAMES

M = EXPECTED NUMBER OF FRAMES

P = MAXMIMUM NUMBER OF FRAMES

Figure 6. Description of Programmed Sequence

Example of Application

During the preparation of PERTeach training materials a behavioral planning network was developed. This network was developed after a complete list of terminal behaviors was prepared. The list of terminal behaviors, the gathering of backup data, general pedagogical outlines, and decisions are usually made before frame writing has commenced. Figure 8 shows an excerpt of the behavioral planning network for the beginning of PERTeach. It is important to notice how some terminal behaviors which are taught late in the program could be taught much earlier if so required.

It is evident in the analysis of any subject matter for a program that the order of the terminal behaviors is never linear. That is, seldom is any given terminal behavior followed by one and only one terminal behavior. In fact, given a fundamental sequence one has many diverse paths to follow. Those paths chosen vary by the pedagogical and technical approach of the

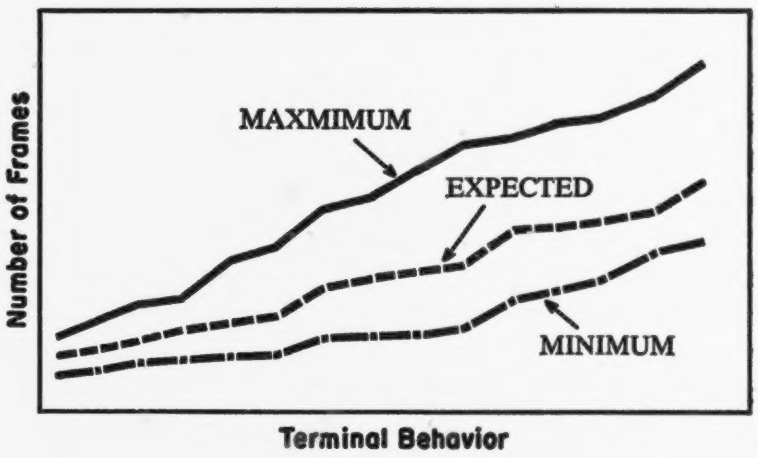
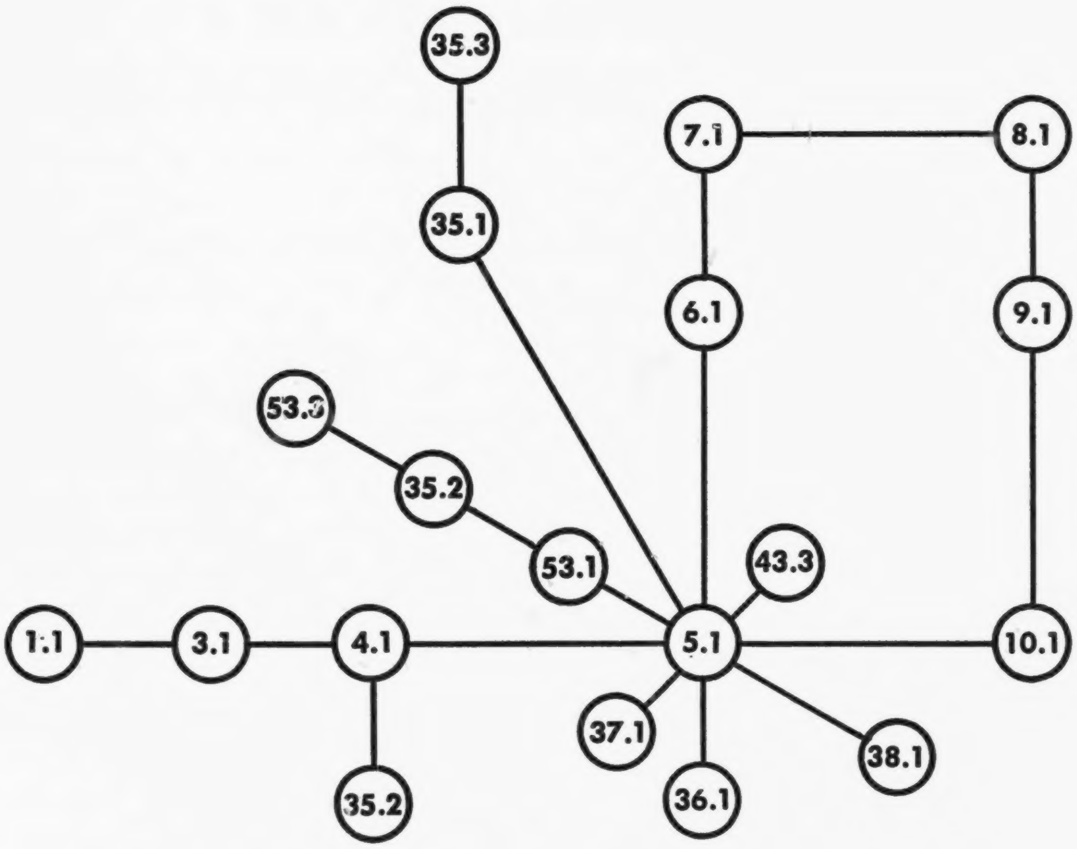


Figure 7. Hypothetical Estimate Based on a Behavioral Planning Network

programmer. The educational and pedagogical strength of the programmer are the only assurance that the alternatives are combined in an optimum manner.

SUMMARY

The usefulness and success with this technique leads us to describe it in more formal terms to allow for its further use and application. The use of a behavioral planning network ensures that an "erroneous set" does not mislead the programmer. This network is also important in assigning and planning programming tasks. Knowing which sequences are dependent upon which, one can assign a programmer to write the first or initial sequence. At the point where there is a branch, one



1.1 Student derives the acronym PERT
3.1 Describes differences between PERT and Gantt-Milestone charts
4.1 Defines PERT activities and events
5.1 Student determines that an event can occur according to PERT rules
6.1 Student determines that an activity can occur according to PERT rules
7.1 When constructing a network, the student includes all activities and events
8.1 When constructing a network, the student eliminates the non-essential events and activities
9.1 Remove closed loops
10.1 Defines a, m, and b
35.1 Recalls that networking is a group activity
35.2 Recalls need for clear identification of activities and events
35.3 Recalls that group members should have common knowledge of the program objectives
36.1 Recalls basic right to left method
37.1 Recalls basic left to right method
38.1 Recalls and uses accepted symbols
43.3 Recalls that updating occurs on two week schedule
53.1 Managers use Security Check List and recall the importance of the PERT data to the enemy
53.2 Managers recall that a PERT network may indicate information classified higher than the contractors portion of the contract
53.3 Program office personnel recall the doctrine of reconstruction and how to apply it

Figure 8. Portion of PERTeach Behavioral Planning Network

may assign a second programmer who now can learn the subject matter in question by taking the frames written by the first programmer. This allows one to quickly add programmers and integrate their styles as a natural function of how the program is constructed and not by fractionating and requiring that each one learn all the subject matter. The ability to estimate properly is necessary for the planning, scheduling, and costing of programming activities. It is important to try to break down estimates to natural units instead of trying to estimate a whole job by rule of thumb. The former type of estimating makes estimates more accurate.

Behavioral planning networks hold promise as a technique of viewing terminal behaviors before structuring a program. They require that a better learning theory be developed and more practice in their application occur before one can clearly state their usefulness.

IV. The Teacher

EDUCATIONAL TECHNOLOGY AND THE ROLE OF THE TEACHER

Joseph A. Tucker, Jr.

With a reputation of being right in the past, Joseph A. Tucker, Jr., makes some thought provoking predictions for the future, a refreshing redirection of our attention to the human element of the technology of education, the teacher and the administrator. He summarizes: ". . . our education in the future will be greatly affected by new technological developments. However, these will be geared to support the teacher and the administrator as well as the student. The type of personal teacher-pupil relationship that we now have will be increased rather than be eliminated. Education will be individualized rather than standardized."

Dr. John H. Fischer, President of Teachers College, Columbia University in a few short paragraphs has listed the research and development areas of immediate concern to educators and educational technologists. In his inaugural address in Riverside Church, New York City, this past fall, Dr. Fischer described Teachers College's opportunities for work in advancing education as a professional human endeavor. He spoke of three broad fields. (I quote from Teachers College Topics):

> First was the "opportunity to focus the energies of education on helping people to find meaning in the world and to find it in their lives". The school, and the humanities in particular, can "expand horizons, deepen insights, sharpen sensitivity". A second opportunity is the chance to investigate further the processes of education. "The connection between the total pattern of the curriculum and what we now call the process of education offers an important and largely undeveloped field for study. The things, the devices, the materiel that can make learning more readily and more widely available and teaching more efficient comprise a third field of opportunity newly open to creative work", President Fischer declared. The most urgent problem is to develop a theoretical approach to the design of educational systems to join the talents and skills of people operating at different levels of competence and responsibility with the capabilities of a variety of mechanical and electronic devices. "Giant strides are imperative here". he stressed.

The latter two opportunities are the subject of this paper.

Both the educator and the developers of educational support equipment are guessing at the future. The incredibly rapid technological developments of the last decade, especially in computer technology and automation have initiated much soul-searching about the future of our educational establishment. Radical change in educational processes and administrative practice has been predicted.

Distinguished advocates of computer technology have envisioned a school environment in which the student working on an individual basis will have much of his learning process actually controlled by computer. It has been intimated that this can be accomplished by 1970. This type of prediction along with the enthusiastic but over-optimistic claims of the advocates of auto-instructional training have caused much concern in the educational community and a major problem in the planning of new educational facilities.

The central issue is the future of the teacher. The concern of teachers about the impacts of new technological developments, particularly automation, is justifiable. If the student is to be controlled in the act of learning through inter-action with computers primarily, the teacher will of necessity have to act as a monitor of the learning process rather than a director of it. Computer control and large scale use of auto-instructional materials require detailed long-range preplanning of instruction. It is this preplanning that lies behind projections of radical change in educational practice. This is not only a problem for the teacher. If this radical change occurs, it will greatly affect the form of products, including textbooks, that are provided in support of education.

I believe the prediction of radical change in the teacher's role is in error. It results from looking at only a small portion of the great technological advances of the last decade and not at all of them. It is ironic that a future of control of learning by long-range preplanning should seem to have logic and inevitability on its side, at a time when technology can make it possible for the short range, personal, clearly individualistic control of learning processes by the teacher to reach the great level of effectiveness which it has always promised but has been unable to obtain due to impossible teacher workloads. Technology could produce "radical sameness" rather than radical change in educational practice.

A major characteristic of present educational practice is that individuation of instruction is a prerogative of the teacher. Granted that there is and must be much planning of educational content for various grade levels and that textbooks, workbooks and tests are based on this planning, one must recognize that the actual conduct of the class is based on the teacher's planning of the work to be accomplished and her execution of that planning. Though this is far from a perfect system, it is clearly differentiated from one in which the teacher is essentially a monitor rather than a director of the educational process. The behavior scientists who speak of auto-instructional training procedures and computer control of the learning process have concentrated on the activity of the student. Few of them have as yet given thoughtful consideration to the role of the teacher. Our rapidly expanding knowledge of how to integrate programmed lessons with other instructional media is largely the result of work by educators and teachers. The educational technologist must support this work. Major emphasis should be given to improving educational procedure through improving the conditions by which the teacher can control it. *TEACHERS ALONE CAN PROVIDE THE TYPE OF INDIVIDUALIZED INSTRUCTION THAT AUTO-INSTRUCTIONAL AND COMPUTER BASED LESSONS SEEM TO PROMISE BUT CANNOT POSSIBLY ACCOMPLISH.* It is necessary to find ways through which the teacher can do the same things that she is doing now far better so that she can truly attend to the individual differences that exist among her students in a learning sense as well as in a guidance sense. Educational technology must include in its mission the increasing of the efficiency of the teacher in a manner analagous to medical science increasing the efficiency of the doctor but of itself not destroying the individual relationship that can exist between a doctor and his patient. There is a need for techniques and equipments which will help the teacher individualize instruction for each student.

Both law and educational tradition have fixed the available time that a student has to get an education. Educators have worked constantly to maximize the effective use of available training time. Much of this planning, in the curricular sense, has been concerned with determining objectives of education. As a result, we now have many curricula for our students. We have greatly improved our facilities for all educational purposes. The intent is to provide an environment in which learning can be accomplished more efficiently than in past environments. In spite of criticism, the objectives as defined by educators have been met acceptably. We do make good use of available training time, but we can make far better use without radical change in our educational methods. I believe that the next great gain in the efficient use of available training time will occur in the improvement of the administrative practices within the classroom. The potentiality of educational technology to save learning time by improving the teachers administration of learning has been lost in the excitement over teaching machines, programmed texts and other innovations aimed at improving the act of learning itself. Though these new techniques are important they cannot be effectively introduced until the teacher can perform more efficiently.

Before discussing how technology can effect and improve teacher-pupil communicative relationship and administrative practice in the classroom, I will dramatize the significance of improving the use of training time at the classroom level by the following oversimplified but logically correct projection. If classroom efficiency can be improved so that five minutes of additional learning on an average can be achieved by the students of each 50-minute class, these students will accrue three weeks additional training time in each academic year. Continuing this projection through 10 years of education from the first grade on, one can note that the total curriculum can be accomplished one year sooner than at present, making one year of additional training available to each student. At a period when great pressures exist to lengthen the school year to provide our students with more education, the possibility of accomplishing it within present time allotments by technological support of the teacher require significant study.

Technological support of the teacher can provide significant improvement in current educational practice in two areas. One is in her control of group processes in the classroom; the other, a corollary of the first, is in the planning of individual assignments for her students.

Group training can be improved by removing many of the inefficiencies in our present methods. These inefficiencies are really simple procedures to which we have become so accustomed that we do not realize the amount of time they waste during any school day. Much of the time of a typical period is spent in "processing" activities, in moving paper about, in tabulating results, in "housecleaning". Technology can make these activities almost instantaneous. The quizzing of students by the teacher, even though they are in a group, can be made private as well as public. Responding of the students, both as individuals and as a group, to questions from the teacher can be accomplished easily and quickly without the time consuming counting procedures we now use. Inquiries of the teacher by a student can be made a private matter rather than one that disturbs the whole class, unless it is in a group discussion or class participating event. Individual assignments can be given to students quickly and efficiently without using class time to explain to each student what it is he is to do. Tests can be scored automatically so that the teacher is not involved in their processing. All of this is possible today with the proper blending of available equipment and can be accomplished far more inexpensively than educators have been led to believe.

The idea of individualizing instruction to meet the needs of each student does not mean that each must have his own unique curriculum. All systematic methods of education, including the auto-instructional techniques, which are really group training methods administered individually, assume that there is a curriculum with subject matters which are to be taught according to a prescribed sequence. This is as it should be. Consequently, the concept of adjusting to individual differences means, frequently, the making of minor alterations in the prescribed sequence in order to meet the immediate needs of the learner.

If one were to ask a parent of a high school student whether or not his child should receive ten minutes of individual attention each week from his teacher, say his history teacher, the parent is most likely to answer "yes" without thinking very much about the significance of a "yes" answer. In fact, one might almost as quickly answer "yes" if the question were stated "Do you believe every child learning history from his teacher should receive ten minutes individual attention per week?" In answering "yes" to a question like this, we do not stop to realize that what we are saying is that a typical high school teacher should spend 25 hours per week at a minimum providing individual instruction to her students. With that fact in mind, let's consider the question again. Does your child deserve ten minutes of individual instruction from his teacher each week? We should think hard before we answer this time. To answer "yes" is to be impractical since teacher time is not available. How about ten minutes every two weeks? This might be possible if the teacher is properly supported. The next problem then is to make maximum use of ten-minute each two week diagnostic session.

In order for the teacher to react to the individual progress of a student, she must have information as to his strength and weakness on a timely basis. The first prerequisite, for individualized training, is efficient assessment of student progress. This must be accomplished in a manner that requires very little time. The second requirement is the actual preparation of an individual assignment for each student by the teacher. This must be accomplished quickly and efficiently since a typical high school teacher will have at least 150 pupils that she contacts each day. Consequently, one of the marks of her professionalization will be that she has such a grasp of her subject matter and the materials available for her students, that she can quickly evaluate the students' performance from the records provided her and make recommendations for the next two-week period. She will have to prescribe quickly and efficiently much as a doctor prescribes. To do this she must have methods of preparing assignments which do not require her to spend considerable time writing out instructions. Further, she must not be required to locate the materials for the student herself. The third requirement is for an efficient way of transmitting the assignments of the student. This again must be accomplished quickly and efficiently with a minimum of time expenditure on the part of both teacher and pupil. Lastly, the pupil must be able to get materials required to accomplish his special assignment as well as his regular assignment with minimum time involvement on his part. All of the essential technological parts to make this type of education feasible now exist. They must be integrated into an efficient component of our educational enterprise.

The achievement of complete capability for supporting education in this manner will take about 10 years. The initial systems will be crude compared to those that will come later. However, they will have all of the essential parts required to support the teacher. The requirement is for equipment which will assure efficient use of teacher time. The purpose is to maximize the teacher's control of learning processes both on a group and individual basis. The need is for a flexibility in educational environment, materials and media that can match the flexibility of individual teachers.

I am certain that during the next five years, educators will begin to use microtechnology, including eight millimeter film and accompanying devices to provide educational materials to students. For example, there is a photographic technique that permits the storing of up to 10,000 images of information on a one 6 by 9 inch card. Such a card can lead to a complete revolution in the method by which educational materials are distributed and handled by the school. This card and its scanning mechanisms can be made compatible with equipment which can reproduce the materials scanned in as many copies as may be required for a specific use. It should be repeated that all of the equipments needed to do this exist now. This will mean that materials for students will not have to be given to them in lump in the beginning of the year, but can be distributed and reproduced for them as needed. Such a capability permits great flexibility in the preparation of assignments for individual students and leads to true individualization of instruction under the tutelage of the classroom teacher. In any case, it is apparent that combinations of new educational equipments will lead to a further professionalization of the teacher's role by bringing the teacher in more intimate contact with the learning activity of each student. Yet these new equipments in no way interfere with the conduct of instruction in traditional manners when this is desired, as it may frequently be. They allow for individual differences among teachers as well as among students. This is desirable. Each teacher can decide which of the new media best fit her own style of teaching. A standardized teacher is no teacher at all. And what is a standardized student? Standards must remain but standardization must go.

Computers of varying capacity will have an important role to play in the application of new technology to improve classroom management. However, it is unlikely that computers will be used to control students' learning as has been suggested in the past few years. Computer capacity can never be used effectively for this purpose. It is impossible practically to accomplish the type of programming that would be required to use the computers' capacity to respond to individual differences since the programming task would be never ending. Much simpler devices can be used to present the auto-instructional programs that can be developed. Consequently, the control of learning behavior by computers so far as conceptual learning materials is concerned is highly unlikely. However, the computer will be very important in making possible a significant increase in the instructor's ability to individuate learning. The computer can handle the data processing parts of this task better than any other available means. Computers can control the preparation of students' records, grades, and the like. Ungraded schools for a large number of students can only be accomplished with the help of computer technology which can keep track, on a day-to-day basis, of the progress being made by the student. In this way, the computer is a helper to the administrator and to the teacher. It makes possible the accomplishment of new techniques of education which educators understand thoroughly but have not previously been able to implement practically.

Computers will be used directly to control the learning of certain types of motor skills. In this, computers are not replacing the function of a human tutor. They are performing a function that no human tutor can perform. This "motor skills" computer-based training technology is embryonic and probably will take 20 years to develop since it requires use of computers of a type about which we have very little knowledge at this time.

I am sure that you all recognize that I am talking about a "systems" approach to the development of an effective learning environment. The theme is to maximize the use of available trainng time. This can be accomplished by maximizing the effectiveness with which all available resources are used. The most important resource of all is the teacher. Yet the teacher is the resource that we use least effectively. Educational technology must produce methods and devices that maximize the effective use of our resources. It must provide instructional aids in support of the administrator, teacher, and student. For much of the curriculum, the need is not for equipment for which one can claim technological wonders in increasing the efficiency of the learning process, but rather for those which, while permitting use of the latest educational techniques, will improve use of available training time by eliminating clerical tasks and poor classroom logistics, providing better use of available training space, permitting more individualized teacher performance, simplifying record keeping, and permitting more flexible curriculum planning. Gains in learning will result indirectly due to improvement in the teacher's work situation and directly from the effect of increased individualization of instruction.

THE IMPACT OF PROGRAMMED INSTRUCTION ON CONVENTIONAL INSTRUCTION

W. James Popham

W. James Popham points out that programmed instruction will take several years before it will make serious inroads on the usual instructional methods of public schools. But when it does, it will achieve greater instructional proficiency because of its significant and salutary impact in six areas: explicit educational objectives, appropriate student practice, student knowledge of results, concern for individual student differences, responsibility for learning and curriculum content. W. James Popham discusses the impact of programmed instruction in each of these areas.

A person experienced in programmed instruction undoubtedly would be in a position to make several fairly safe predictions regarding the future of this area. One highly defensible prophecy would be that programmed instruction methods will never totally replace more conventional instructional procedures. In fact, it will take a few years until programmed approaches make any serious inroads in the usual instructional methods of public and private schools. As a parent of school age children, and a programmed instruction proponent who has been somewhat less than ecstatic over the quality of currently available programs, I confess I do not view this prophecy with total dismay.

Actually, this kind of prediction could have been made some time ago with equal assurance of fulfillment. It occurred to me several years earlier as I was caught up in a swirl of enthusiastic excitement about the potential of programmed instructional procedures, that conventional classroom instructors could profit tremendously from studying the methods of the programmer. And since it was patently clear that the classroom teacher would have to wait years until a sufficient number of suitable programs were available for his use, it seemed a tragedy that certain techniques of programmed instruction could not be infused into the pedagogical repertoire of the conventional teacher. I, therefore, have found myself increasingly drawn to this task.

Now someone could correctly observe that most of the elements of programmed instruction have been known to psychologists and educators for many years and that it's about time teachers started making use of them. It seems to me that in order to change the behavior of teachers, and for that matter the teacher of teachers, something more dramatic than esoteric, albeit conclusive, research reports was needed. Programmed instruction has supplied that drama.

It is not too uncommon for an instructor who teaches an introductory course in programmed instruction to have teachers in his class, at the conclusion of the course, remark, "I may never be a programmer, but this course will make me a better teacher." Why should this be so? In other courses in a teacher education curriculum, courses which are ostensibly designed to improve the teacher's instructional proficiency, such comments are rarely forthcoming. I believe that a teacher's exposure to the methods of programmed instruction can provide a stimulus of sufficient strength to affect a teacher's usual instructional methods. More important, programmed instruction is shaping the behavior of instructor trainers and teacher educators. Such influential individuals are now beginning to incorporate programmed instruction principles in their own teaching repertoires and to advocate their students' use of them.

It is true that such influence is only beginning to be felt, but in a relatively short time I believe we shall receive significant classroom dividends wherein the teacher faced with 30 grade school children, 35 high school pupils, or 100 college students, will manifest greater instructional proficiency because of the impact of programmed instruction.

It seems to me that there are at least six easily discernable instances of influence that programmed instruction has begun to have on conventional instruction, influences that will become markedly stronger in the next three or four years. I shall briefly discuss each of the instances, recognizing that other attributes of programmed instruction may in time make very striking contributions to conventional teaching procedures, perhaps even more significant than those which I shall identify.

The first, and to me the most significant, impact that programmed instruction has had on conventional instruction is in the field of instructional objectives. As we know, programmers generally specify instructional objectives in terms of student behavior. Classroom teachers generally do not. Instead, classroom teachers usually preface a description of their instructional plans with high sounding but wholly ambiguous assertions such as "The student should improve his ability to meaningfully deal with the underlying causes of the Civil War."

Of course, such loosely specified educational aims offer little assistance to the instructor, either for the selection of learning activities or for the evaluation of instructional effectiveness.

Now even though Bloom's carefully detailed *Taxonomy of Educational Objectives* has been available to educators for seven years, few classroom teachers have indicated an awareness of the need for operational instructional goals.

Currently, with the focus of programmed instruction on explicit objectives framed in terms of student rather than instructor behavior, I note an increasing recognition on the part of public school personnel that there are strategic advantages in stating specific instructional objectives. More important, educators are beginning to stress the value of such objectives in their pre-service and in-service professional classes.

No small part of the credit for this development should go to programmed instruction specialists such as Robert Mager, who have emphasized the need for behavioral objectives in their writing and public speaking engagements. Mager's excellent little volume on how to prepare instructional objectives has been used extensively during recent months in a number of teacher education programs. I stress the criteria for well stated objectives in a required curriculum and instruction course. One must assume that some of this attention to objectives will eventually be translated into a teacher's behavior. It is important to note that just a few years ago, that is, before the impact of programmed instruction, this emphasis of explicit objectives was not present at many teacher education institutions.

A second influence on conventional instruction, which is in large measure attributable to programmed instruction, involves the necessity of having the learner make active responses, which are appropriate to the instructional objective in question. Far too often conventional instructors, who really have most desirable instructional goals in mind, design learning activities for their students which are, at best, only peripherally relevant to these goals. The programmer soon discovers that if he wants a learner to engage in terminal behavior X he must provide many opportunities throughout the program for the learner to practice behavior X. We cannot build a program featuring many instances of the students' use of behavior Q and expect him to leave the program imbued with behavior X. As F. Rand Morton has cogently observed, through the use of an exclusively verbal or textual program you may be able to teach a prospective sales clerk that she should smile at customers, you may even make her want to smile at customers, but to make her smile at customers you must build a program that allows her to receive reinforcement for actually smiling. In other words, the program must contain opportunities for the student to engage in appropriate practice.

Thirteen years ago Ralph Tyler in his University of Chicago curriculum and instruction course was urging precisely the same thing. Why has it taken programmed instruction to change the behavior of the conventional instructor? Perhaps for the same reasons we are told a programmer must condition a few rats or pigeons before he can comprehend the true power of behavior-shaping principles, so, too, a conventional instructor may have to try his hand at changing an individual student's behavior by preparing a systematic program before he realizes the significance of student response, and for such responses to be relevant to the instructional objectives. You don't have to fail too often at programming fairly simple instructional material before you start looking for explanations. Quite often the teacher discovers the real culprit in his unsuccessful program is the lack of appropriate practice. Such notions, fortunately, are beginning to show up in the conventional classroom.

A third principle of programmed instruction, which is being incorporated into conventional instructional approaches, is that of immediate knowledge of results. The notion that the student should learn quickly of the appropriateness of his responses is almost universally practiced in programmed approaches. It is not surprising, therefore, with teachers being increasingly exposed to programmed instruction, that the knowledge of results principle should find its way into conventional classrooms. This is perhaps the most easily incorporated programmed instruction principle, and part of this recent increase in teachers' use of the principle is undoubtedly a result of the fact that they can introduce it so easily to their regular classroom procedures. I note from a research study that student teachers of a certain university who have been urged to used this principle do employ it in their classrooms with greater frequency than student teachers for whom this principle was not emphasized. Personally, I do not consider this principle one of the greatest contributions made by programmed instruction, but I do believe the increased influence with which it is used in regular classrooms is directly attributable to its widespread employment in programmed instructional methods.

The fourth area of impact which programmed instruction has made on conventional instruction is quite different from the former three. In this instance, the stress on self-pacing or individual differentiation seen in programmed instruction has not been translated into conventional instruction practice. True, classroom teachers have urged individual differentiation for years, but few have really tried to implement this principle.

Fortunately for a teacher's tranquility of conscience, the gross injustices done to exceptional students in a non-differentiated conventional classroom rarely are clearly evident. With the self-pacing features of programmed instruction, such atypicality often results in startling reductions in the time supposedly required to master a subject. Teachers cannot hear the fairly frequent accounts of how bright students finish whole year courses in half the time without being struck by the fact that allowances for such differentiation are rarely made in the conventional classroom. In other words, with respect to individualizing instruction, programmed instruction has induced a great many guilt feelings among conventional instructors. So far, that's about all it is, guilt, but, with time and conscience qualms mounting, I believe we can expect greater concessions to self-pacing in the conventional classroom.

The fifth significant contribution that programmed instruction has made to conventional instruction relates to the implicit reliance on student testing to improve the quality of programmed instructional material. As we know, programmed instruction has largely shifted the responsibility for the quality of instruction from the pupil to the programmer. Many conventional teachers are impressed with the fact that programmers are willing to accept this burden of proof and put their instructional effectiveness on the line by testing a program's quality in terms of student behavior.

Certain classroom teachers are actually beginning to view unattained instructional objectives not as the fault of "inattentive students" but as a reflection of their own instructional inadequacies. Whatever influence programmed instruction has in promoting this type of attitude will yield remarkable benefits to many pupils, pupils who will profit from a teacher who is willing to modify his instructional behavior if his students fail to reach the heights he had in mind for them.

The sixth contribution of programmed instruction to conventional instruction, which I shall designate as "curriculum concern", may well have the most far-reaching effect upon the schools. I became aware of this sixth point when my students in introductory programmed instruction courses would voice a wide-eyed observation: "You know, this method works so well we've really got to be careful about what we program!"

True enough, as any instructional method becomes increasingly effective, a proportionate increase in attention must be given to its content and objectives. One of the consoling features of conventional instruction is that it is often so ineffective that we don't have to worry too much if the wrong curriculum is employed. As instructional methods, both programmed and conventional, become more capable of achieving their objectives, we shall see an even greater concern regarding the appropriateness of the curriculum.

Already there have been several instances when programmed instruction experiments have been criticized, not for the quality of the programs used, but for the content selected. The same will be increasingly true with conventional approaches as they become more effective.

In summary, I have briefly examined six contributions which programmed instruction has made to currently employed conventional instruction techniques. Some educators fear that programmed instruction will have undesirable influences on conventional instruction, and it will! Lazy teachers will rely too heavily on poor programs. Economy-oriented administrators will try to spread over-worked teachers too far by using self-instruction materials. Yet, even though these unsound uses of programmed instruction will occur, and taking no account of the obvious instructional benefits of good programs themselves, I am thoroughly convinced that the residual impact of programmed instruction will be significant and salutary.

A VENTURE IN PROGRAMMED INSTRUCTION

Sister M. Dorothy, C.D.P.

Sister M. Dorothy reports on her trial of TEMAC Basic Math, 3600 I frames, and TEMAC Algebra I, 8000 I frames in her eighth grade at St. Martin Hall Grade School, the campus laboratory school of Our Lady of the Lake College in San Antonio, Texas. She indicates its use was successful and points out both the advantages and pitfalls of the use of programmed instruction from the point of view of the students as well as the teacher.

An experiment is now being conducted in eighth grade mathematics at St. Martin Hall Grade School, the campus laboratory school at Our Lady of the Lake College in San Antonio, Texas, in conjunction with the Education Department, on the comparative efficiency of programmed instruction with the traditional type of mathematics instruction. A control group of students was selected in another eighth grade in another school having a comparable number of students. Intelligence tests and mathematics achievement tests were given to both groups before any instruction began. Five weeks later, copies of TEMAC Basic Math, published by Encyclopedia Britannica, were distributed to 37 eighth grade students in the experimental group.

The use of this new type text was carefully explained to the students. Mathematics was scheduled for 50 minutes daily; however, the use of the TEMAC books was not restricted to the daily class period. Students were told that they might take the books home although there was no obligation to do so. Tests were to be taken upon completion of a specified number of frames and when students felt ready for them. During the mathematics period the teacher was available for help, direction, explanation, or just plain encouragement. Very few children needed or asked for help. Only twice, near the beginning of the course, was there a general class discussion of the problems in the texts. The students were advised and soon realized that when they came upon a problem that was troublesome or that they did not understand, the wisest thing to do was to go back to the frame in which the material was first presented. After rereading the explanation and reworking the problems if necessary, students were generally able to proceed without trouble. In the cases where this was impossible, individual help was given.

The majority of the students proceeded confidently and steadily through the 3 volumes of Basic Mathematics covering some 3600 frames. The first two students finished Basic Mathematics in five weeks. After 21 weeks, 35 students had completed the 3 volumes while two students had not completed the third and final volume, but had completed the first two. Upon the completion of the Basic Mathematics the students were given a list of approximately 75 pages from the traditional mathematics text ordinarily used in the eighth grade. These pages included some of the material covered in TEMAC, but since it was presented in a different way it served as a review. The types of problems included insurance, taxation, mortgages, and various other problems involving the application of percentage, geometric constructions, and measurements and a section on introductory algebra.

After the material was satisfactorily completed, students were allowed to begin TEMAC Algebra I. This course consists of 5 volumes having in excess of 8000 frames and 30 unit tests. About half of volume 5 is devoted to a cumulative review of the course. There are 6 more tests to accompany this section.

By the end of the school year, 2 students had completed the course in Algebra I, while 20 others were at various stages of completion. Of this number, 3 students were working in volume 4; five were in volume 3; and the other 12 students were evenly divided between volumes 1 and 2. Time did not permit these students to complete the program. Motivation for these eighth grade students did not seem to present any difficulty. When the books were distributed, the students were told that there would be no definite daily assignment and that they were to be on their own. Some settled back in their desks while smiles reflected complete approval of texts and procedures. Diligence soon replaced any tendency to lazy complacency and with few, if any, exceptions the children made consistent efforts to use the programmed texts efficiently.

The very nature of the texts afforded motivation by its immediate reinforcement of each fact or concept learned. The interweaving of instruction, drill, and testing held the children's interest and there was no appreciable tendency toward boredom. In order to help forestall such an eventuality, students were told that when they came to a group of problems drilling on a process they knew, to work the first 3 or 4 problems and, if correct, to skip the rest.

Although an attempt was made to eliminate human competitiveness as a motivation factor, by telling the students not to worry if a classmate was ahead, no one wanted to be left far behind. Another important motivating factor was the feeling of accomplishment upon the completion of a book or volume. A certain feeling of justifiable pride was felt by the individual as he put aside one volume and began another.

Chart I gives a graphic view of the number of students finishing Basic Mathematics in a particular number of weeks. In examining this chart, it may be interesting to note that the 2 students who finished in 5 weeks were outstanding students. The next group, who finished during the 7 to 9 week period were very good to average. Not all of these 8 students attained the highest scores on the tests nor on the achievement tests given in September and in January. At least 2 of those in the 20 to 21 week group had an excellent mathematics record in previous grades and they also had high scores on the achievement tests. This seems to point up the ever present problem of speed vs. accuracy. One student clearly recognized this problem. After several very low test scores, he saw his error in working too fast and asked to repeat almost an entire volume. This experience helped not only the individual concerned, but also the entire class.

A further study of this chart leads to a consideration of several problems involved in the use of programmed texts. Students completed the program at various times; individual help was needed from time to time; and tests were administered at different times with discussion of errors a must. Students who completed programs had to be given interesting and challenging materials to follow up the program and to provide sequential learning. Adequately meeting these needs required full-time attention to detail.

Another problem was grading and reporting to parents. Since the students were working on an individual basis, it was impossible to give them a percentage or letter grade in relation to other members of the class. In order to give parents a picture of their child's progress, a mimeographed report was inserted in a regular report card, showing the possible number of points per test, the number of points made by the child, and the equivalent percentage grade.

Number of Students		*Percentage Average*
A*	4	95.5 - 97.5
B*	8	90.2 - 94.5
C*	15	85.4 - 89.8
D*	8	81.0 - 84.5
	1	79.8
	1	66.0

Percentage averages on 8 tests in TEMAC Basic Mathematics
* For comparison in using Table II

Table I

Table I shows the average percentage grades made on the 8 tests which accompany Basic Mathematics. The numbers of students falling within particular percentage intervals have been indicated. These figures give a nearly perfect curve with the largest number falling within the 85.4 to 89.8 interval.

Table II shows the progress of those students who are now working in algebra. The letters A, B, C and D indicate the average intervals taken from Table I for each student in Table II. With two exceptions the students made satisfactory progress. The student from group "A" with an 83.0 in algebra may need to repeat or reread part or all of volume 1 in algebra. The girl from group "D" who was extremely eager to begin algebra worked slowly, but with determination, and repetition seemed necessary at each step. Her understanding and progress had to be carefully checked.

As students finished Basic Mathematics and took up the traditional text, a carryover from the programmed text was apparent. For the most part they seemed capable and desirous of carrying on as they had done in TEMAC. Explanations and problems were carefully read and attempted. A gratifying feeling of independence and self-confidence seemed to have developed and

Tests Taken	*Average on Algebra Tests*	*Average in Basic Mathematics*
30	96.4	A
30	95.8	A
26	96.2	B
22	92.5	A
19	94.7	B
16	91.2	A
16	92.4	C
10	92.6	B
10	91.0	B
9	89.3	C
8	88.8	B
8	83.6	B
7	85.4	C
7	94.5	B
7	90.0	C
6	73.0	D
5	89.2	C
4	94.0	C
4	89.7	C
4	88.8	C
3	83.0	B
3	99.3	C

Percentage averages on TEMAC Algebra tests

Table II

they approached word problems and others without the usual hesitancy.

An examination of Table III shows the grade placement gain of the students from September through May. The interpretation of these data may be misleading unless it is borne in mind that the lowest amount of growth is shown for students who scored very high on the tests in September. Since the tests, Sequential Tests of Educational Progress, are designed specifically for the use of eighth grade, it is possible they do not make adequate provision for the high achievers. On the other hand, the greatest gain is shown by students who made the lowest scores on the first test. Many times this question is asked, "How do others at St. Martin Hall, teachers, parents and students, feel about programmed instruction?". The other teachers are very much interested in the results of the eighth grade study and they are eager to try out programs on their own level. If and when programmed instruction becomes the accepted and usual practice, propaganda or persuasion techniques will not be necessary for this faculty.

Parents' reactions have varied from enthusiastic to skeptical. Most of them seem to have adopted a "show me" or "I'll wait and see!" attitude. Following a very interesting and enlightening discussion of programmed instruction during a P.T.C. meeting, one parent seemed to reflect the feeling of the group in these words, "I'm sure this type of teaching must be good but I don't really understand it. When my 3 daughters were in 8th grade I knew exactly what they were doing, but I have no idea of how or what my son is doing".

What about those most directly concerned, the eighth graders themselves? Their reactions also are varied and I would like to share some of their comments with you. In attempting to find out how the eighth graders felt about programmed texts, several lead questions were proposed. When asked if they liked programmed instruction, all 37 answered in the affirmative. Four students answered "no" to the next question, "Would you like programmed texts in other subjects?". The other 33 students expressed a desire for programs in every subject and especially in English and Science. The last question asked for a brief statement setting forth reasons for liking or disliking programmed texts. Some of their comments were:

Grade Placement Gain	*Number of Students*
.0 - .4	4
.5 - .9	10
1.0 - 1.4	11
1.5 - 1.9	7
2.0 - 2.4	3
2.5 - 2.9	2

Grade placement gain from September to May

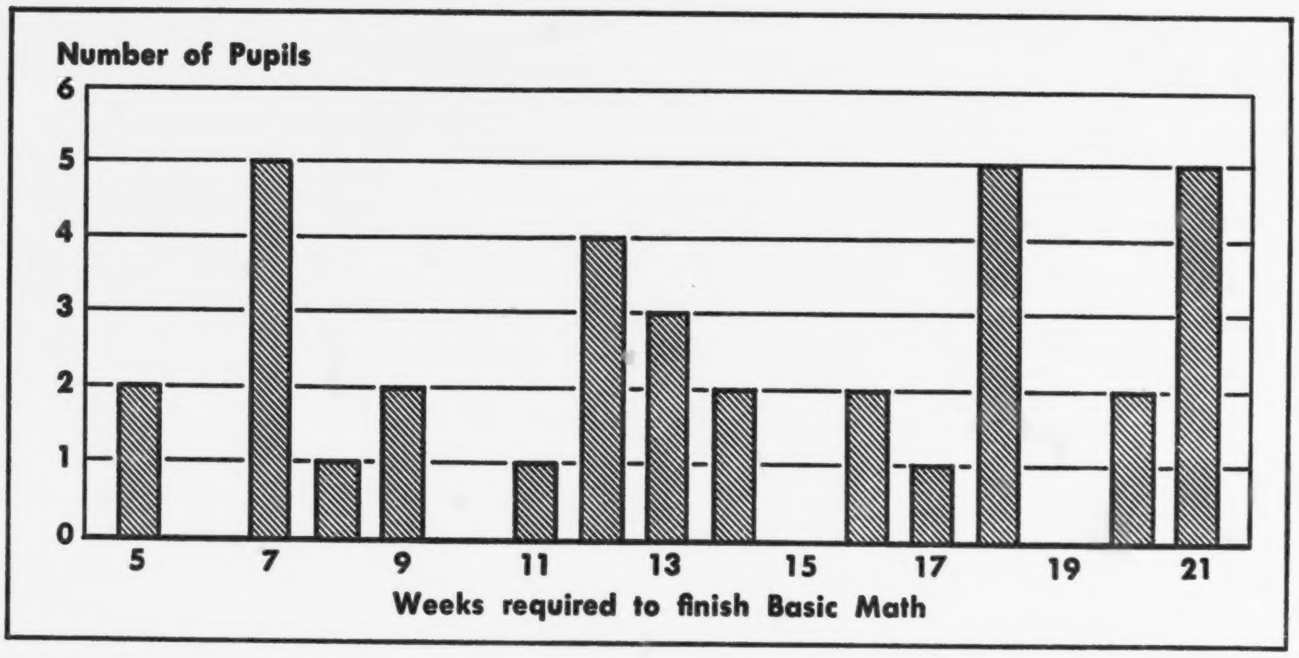
Table III

Sophie: "I like TEMAC because it taught me new ways of adding, subtracting, multiplying, and dividing. The one thing I did not like, was not having a definite assignment every night. If I don't have an assignment, I don't work".

Tally: "I think I learned a lot. You can go at your own pace. You do not have to wait for others or if you want to go slow no one pushes you through".

Susan: "I like the mathematics and algebra. When I have worked for a while I feel like I have accomplished something".

Richard: "I like this course in mathematics for many reasons. Mainly because we do not have regular classes; we do not have to be teacher-taught unless we have trouble; homework is not required; and we may go at our own speed. I think our eighth grade has an advantage over many schools".



Becky: "I like TEMAC because you may go at your own speed without hindrance and you may take your tests whenever you want them".

Priscilla: "I think you can learn more with TEMAC if you are willing to work. It enables you to work quickly through the easier parts and slowly through the more difficult parts".

Joe: "The biggest help in using TEMAC is that the minute you make a mistake you are corrected".

Judy: "I used to be very poor in mathematics, but with these books I have really brought my grades up".

Cynthia: "I think programmed subjects are fine except for one thing: they leave out class discussion, an important factor in learning. One subject only, such as mathematics, should be programmed".

Michele: "I think that programmed instruction was an interesting way to learn mathematics. Although sometimes you get very tired of going over the same problem more than once, I suppose it's necessary since you don't have a teacher giving out extra practice problems. I feel that I have learned a great deal this past year. I'm sure it would be very helpful to have programmed instruction in other courses, too".

Mary Ellen: "I enjoy programmed instruction. The way the material is presented helps me to grasp it much more easily than an ordinary text, which I need a teacher to explain. There is the additional fact that it is possible to go over your own grade level to more advanced work".

In conclusion, I should like to say that I am happy to have had the opportunity of using programmed instruction. While I realize very well that it is not an educational panacea, I am fully convinced that it has many possibilities and tremendous potentialities. As educators, whether in the position of teacher or of administrator, I do not think that we can afford to be ignorant of the aspects of programmed instruction.

PROGRAMMING A COURSE IN WORLD HISTORY

Robert La Fontaine

Robert La Fontaine, a public school teacher, describes some of the problems in social studies areas, a tentative approach built on programmed instruction, and the effectiveness of an extensive history program he is writing and using in his own classes.

The field of social studies and in particular the area of history has been, for the most part, generally ignored by those engaged in the creation of programmed material. Some have claimed that the social studies are too flexible to be properly programmed. And yet, if any subject area presented in today's schools needs a new medium of instruction, it is most certainly the social studies. In no other area does one find such large textbooks and so little real learning taking place as in the area of history and related subjects.

The blame for this unfortunate situation cannot be placed upon the textbook publishers. They are producing textbooks to fit the requirements of the schools. Unfortunately these requirements were formulated back in 1914, almost fifty years ago. As a result, teachers today are faced with a tremendous volume of material to teach, with too little time, in most cases, to teach it. The state of Texas is a good example. In the seventh grade, students spend a full school year studying two hundred years of Texas history with time to spare. In the eighth grade the year is spent studying four hundred years of United States history. Ninth or tenth graders spend the same amount of time studying five thousand years of world history. As you can see, between American and world history there is over a one thousand per cent increase in time span. This pattern of social studies courses is repeated in almost every state of the nation. Particularly in the field of world history with its tremendous volume of material is there an almost desperate need for more efficient means of presenting the subject. This same trend is also developing in the field of American history as we attempt to add more information or to delve deeper into the subject at all levels.

The social studies also has another obstacle not usually present in other areas. Since it is not (or should not be) a purely factual subject, it is almost impossible to hand the student a history textbook and expect him to appear the next day with anything resembling organized complex thought. Even with a well organized text, the problems of varied reading ability and the inability to extract only the important material from the context because of the lack of basic repertoire in the area lead to defeat in many cases. As a result, reading assignments from the text are often challenges requiring the student to learn from the text those associations he thinks the instructor thinks the author believes are important. Often the student is completely incapable of doing so.

Because of this situation, much of the time in the conventional social studies classroom is spent in sorting out, exploring, and explaining the material found in the book. This, of course, leaves little time for other things, particularly for the study in depth of the great people and events of history. Perhaps this dehumanization of the subject is the reason for the apparent lack of interest on the part of the students for this area of their studies. History *is* people; without them, there is no history, yet students often perceive history as having no "human history."

In recent years an attempt has been made to return the great people and events to the history books by following only the important developments of western civilization from beginning to end with only a minimum of attention being given to factual material. This method can be called the "concept school," as opposed to the "facts school" which only skims the factual surface of history. Neither the "facts method," which leaves out people, nor the "concepts method," which ignores facts, is a satisfactory solution to the problem of cramming five thousand years of history into the minds of our young people in one pitifully short school year.

Perhaps a well-developed program could offer relief, or even a solution, for this dilemma. Most educators recognize that both facts and concepts (i.e., critical complex thinking) are important in the field of social studies. Most will agree, however, that it is very difficult to obtain one without the other. In the sciences how can complex thought be developed with reliance upon facts? This seemingly presents quite a challenge to the medium of programmed instruction, and it is this challenge of teaching both facts and concepts that most programmers have avoided. Admittedly, it is an almost impossible task, particularly since it is rather difficult to find two historians or even two teachers who agree on all the important concepts of history.

But ours is not the task of solving the world's problems or even the problem of those who teach social studies. In fact, ours is not even the problem of telling the teacher what or how to teach, much less attempting to replace the teacher. Strangely enough, this may be the key to the solution of the problem.

If a program could be developed to present one side of the social studies story so well that the teacher need spend very little time on the material in this area, then this precious time could be spent in developing the other area effectively. At this point let us will the controversial and somewhat fluid area of "concepts" back to those brave enough to teach the subject, and from henceforth deal with the "easy" area of history, the facts. In this manner we have created a medium more familiar to the programmer and most certainly one he is quite capable of handling. Admittedly, we have sidestepped a major challenge, to produce a *complete* program in world history, but this can wait for future development and growth in the field of programmed instruction. Our immediate problem is to produce a package that will enable the classroom teacher to do an effective and efficient job of teaching a complete course in history. This can be accomplished by removing the burden of teaching factual material, thereby enabling her to devote class time to the development of concepts and critical thinking in her students. Thus the main objective of a program in world history is to present to the student a solid foundation of factual material, a basic repertoire, on which a teacher can build an interesting, detailed, and challenging study of world history. This type of program can be called a foundation program, since its sole purpose is to provide a solid foundation on which a teacher can build a complete course. Like a building, its final height depends upon the goals of the designer as well as on the firmness of the foundation.

The purpose of this program in world history is to teach the student in as short a time as possible the facts of history so that he can utilize this knowledge in the classroom under the guidance of a capable teacher. In the program, therefore, we are concerned with such factors as the location, names, dates, persons, events, causes, effects, and contributions of the major civilizations of the world.

This type of material lends itself quite readily to the Skinnerian, or linear, format of programming. The major problem involved is that of introducing new material, since, unlike mathematics or science, there is little basic repertoire or knowledge that can be expanded upon. To introduce this new material without overloading the program with copy frames, extensive use was made of display panels consisting of pictures, charts, or time lines. From these, the student can obtain, with a reasonable amount of searching and thinking, the necessary information to complete the frames.

Other than the extensive use of panels, there is very little difference from the conventional type of linear program. The frames are brief, in most cases, and require an overt (written) response on the part of the student. On the trial runs the responses are written directly on the program but of course this will be changed in the future to make the package reusable.

The standard techniques of review and criterion test frames have been used to check on the progress of the student. The program also incorporates, with varying degrees of success, the use of wash-back or review techniques for the slower student. One problem in this area is the conservation of frames. With a program of this scope, the number of frames could easily get out of hand and begin to climb toward rather impractical numbers.

Post-tests are given at the end of each chapter, and, in the cases of very long chapters, at logical subdivisions within the chapter (at approximately two hundred frames). The post-tests are of the objective type, requiring written recall responses.

The program in world history is being tested on two groups of ninth grade students at John Nance Garner Junior High School, Northeast Independent School District, San Antonio, Texas. This course is generally a tenth grade course, but is being offered at the junior level for the academically talented student. Listed below are some general characteristics of the two groups.

	Size	Age	Mean IQ	Median IQ	Range
Group 1	30	13-14	120	121	98-145
Group 2	28	13-14	122	120	103-143

Both the test groups and several control groups of the same caliber were given a standardized pre-test at the beginning of the year. This same test will be administered at the end of the year to see if there is any significant improvement by the test groups over the control groups taught by the conventional method.

At the present time it is impossible to arrive at any final conclusions as to the results of the program since it has not been completed. The most that can be said is that the technique does work. The students have found the program interesting and in some ways challenging, and have continued to work on the program with no pressure from the teacher. In fact, some of them have taken more of an interest in programming than they have in the subject itself.

Of major concern was the fact that the program was being tested for the first time on rather talented students. There is a possibility that such students could do well on any type of material, thus making invalid any test results derived from these students. To combat this problem, the slower students of both groups, who approach the national norm, were carefully observed.

The chart below is a comparison of the grade averages of the top five and the bottom five students from Test Group 1.

Student	IQ	Average: 6 Test Grades Frames 1-500	Average: 6 Test Grades Frames 501-1300
1	145	97	93
2	139	96	92
3	136	95	87
4	135	95	82
5	132	98	85
Average, Top Five		96	88
26	108	88	82
27	106	96	95
28	104	98	88
29	100	87	90
30	98	83	50
Average, Bottom Five		90	81

There are differences in their grade averages. But with the exception of student #30, who dropped the course at mid-term, the slower students showed a gradual improvement in their grades even though the material became more difficult.

Admittedly, the grades are not as high as would be desired since they do not attain the goal of ninety per cent of the students knowing ninety per cent of the material. However, on some of the post-tests this goal was attained, and on others the results indicated that the goal probably could be attained without drastic revision of that section of the program. At the present time there is one section that probably needs rather extensive revision.

Even though there are no final results upon which to judge the results of the program in world history, it is possible to arrive at several general conclusions:

1. The idea of a foundation program does work. With the test groups, not as much free time has been attained as was first considered possible, but this was due to the time involved by the instructor's having to research, write, type, and mimeograph approximately 260 pages of material. A prepared program would allow the classroom teacher relatively large amounts of classroom time to explore the subject in detail.

2. The novelty effect of the programmed material does not seem to diminish to any great extent because of several factors:

a. Constant high grades are encouraging to the student.

b. Logical and careful sequencing of the material makes the information easy to learn.

c. More class time for discussion and research make the subject more interesting.

3. The completion of a set of frames for homework leaves the student with a sense of accomplishment of actually having learned something, an experience rarely found with textbook assignments.

4. Spelling accuracy generally improved because of constant repetition of important words.

5. The slower learner does not become lost and discouraged as the material becomes more complex and detailed, but actually improves with time due to the highly organized nature of the program.

6. Programming a course in world history is no easy task. But for a teacher concerned with the problems of helping students learn, it is a rewarding one.

PROGRAMS IN THE LANGUAGE ARTS—AVAILABLE AND DESIRABLE

F. Allen Briggs and Robert K. Branson

This discussion between F. Allen Briggs and Robert K. Branson brings out the difficulties often encountered between teacher and programmer. Mr. Briggs suggests that specific skills in language arts instruction can be programmed. He points out, however, that in many areas there is disagreement about "correct" answers which will hinder programmers. He argues for programs that really teach as opposed to programs that are merely exercise books. Mr. Branson, speaking for the programmer, wants clearly defined objectives from which to program language arts. He feels that programs in the areas of appreciation and reasoning will have to be written and tested to prove that such programming is possible.

Mr. Briggs: Language Arts is an area of study composed of many specific skills, the application of which produce efficient language usage. Not only may the field be divided into the traditional parts of reading, writing, speaking, and listening, but under these general divisions there are such specifics as spelling, grammar, punctuation, vocabulary, paragraph form, rhetoric of different forms of larger units, the attribution of sources, reading skills, imagic devices, and many others. Because so many different things are taught in the language arts classroom, there is a great deal of room for auto-instruction.

Although these different skills may be mutually supporting, there are many areas which may be studied in a varied sequence. Different from the discipline of mathematics where addition and subtraction skills are necessary before multiplication and division can be efficient, language arts skills are not so rigidly sequential. The breadth of choice makes it possible for a teacher to select an area for programmed teaching which may be used with most of the members of a given class. On the other hand, there is a sequential feature within most of the skills; some of the grammar skills should be learned first, and later in the school experience of the child, more advanced grammar skills are in order.

Mr. Branson: Although it may be very desirable to think of utilizing the strengths of programmed learning in the language arts area, there are probably other changes which would benefit the field to a greater degree, i.e., if every teacher of every subject from grade school through the university would insist on his students writing in the English language and not accept his materials written in only an approximation of English, then symposia, panel discussions, and many controversies in the field of language arts would be essentially eliminated because the negative aspects of language teaching in the language arts area would have been eliminated.

Mr. Briggs: There are certain generally recognized limitations of language arts teaching, and many of these limitations are complemented by the strengths of programmed instruction. In the first place, most school children are expected to learn the skills assigned to a given year although they have not mastered the skills taught the previous year or years. At this point, programming's emphasis upon mastery of a skill before the student goes ahead to the next level will free the student from lock-step enforced inability to learn. In the second place, the frequent review and reteaching made necessary by incomplete mastery at all levels often forces a student who has done his work to repeat something in which he is not interested. Programming's ability to allow each individual to work at his own rate and at his own level will prevent the boredom (and consequent disciplinary problems) of needless repetition.

In language arts, as much as in any other subject, the partially acquired skill is of minimum value; programming should allow emphasis upon fundamentals until maximum proficiency in the minimums has been attained.

Mr. Branson: Programming like any other method of teaching in the language arts area suffers from a certain limitation. Perhaps we ought to decide sometime if we are going to teach "about English" or "how to use English." The terminal behavior in either case would be different. There is considerable doubt that teaching about English will improve one's ability to use the language. With few exceptions, most of us speak the language far better than we write it. I agree with those who contend that this occurs because we learn to speak the language without ever going through a procedure of talking about the language.

Mr. Briggs: Although there is general agreement about desirables, there is little agreement among "experts" in language arts about how the attained skills may be measured and even less common ground about the correct path by which the objectives may be attained. Most teachers agree that the child should read, write, speak, and listen expressively and efficiently; all of them try to help their students do better.

On the other hand, methods by which these skills can be evaluated are violently questioned, and even greater disagreement exists concerning the level of performance which may be expected at the different levels of schooling. In a number of the sub-disciplines, there is almost no agreement as to the most effective path toward proficiency. In grammar the battle between usage, prescriptive and linguistic proponents wages so high that no program could satisfy all three, and the "separated" as opposed to the "fused" methods of teaching often cause real quarrels in language arts circles.

There have been a number of studies made which give some indication of the grade at which certain skills should be taught, but these studies have not become effective at the level of the curriculum of the individual school. There are still many teachers who attempt to teach the children all they know at any grade placement.

A fourth difficulty for the programmer is the difficulty of ascertaining the "correct" answer in many language situations. In some, such as spelling or the agreement of verb and subject, the correct answer is relatively unquestionable and may be used as a confirmation in the usual sense. In others, there are a number of answers which may have relative degrees of "correctness" and the use of one of them as a confirmation (even if it is understood that another answer "which says the same thing" or "which accomplishes the same end through different means") will result in a lack of freedom sufficient to make the attainment of goals of individuality impossible.

Many of the programs now on the market seem to have confused the knowing how to do with the ability to do; they offer statements of principle and drill in "exercises"; no more than in the least effective conventional instruction do they provide for transfer into the student's own writing and speaking. In point of fact, many of the programs now on the market are really nothing except workbooks, chopped up into frames, and with the teacher's manual or key also supplied in bits.

In using the new device of programming in language arts, there seems little advantage, other than commercial, in perpetuating the faults of the present system. The new wine of individual pacing and confirmation may well serve to burst the old wine skins of busywork with a minimum of learning.

Mr. Branson: Professor Briggs has made a very good point in elaborating some of the shortcomings of programs on the market which deal with the problem of the desirable terminal behavior for the student. So far no one has written a program that can establish "creativity," "originality," or other highly desirable features. On the other hand, some have vastly improved their ability to be creative and original by using programs available on the market. Some students have been able to transfer behavior established by the program. Others have learned what is in the program, but have not shown improvement in their ability to write the language. Another problem that the programmer faces in developing material for us in language arts is that of defining acceptable terminal behavior.

Mr. Briggs: Some real attention might well be given to the presence of multiple language levels, i.e., one writes differently than he speaks—sight recognizes words which he never hears, and is impressed by different rhetorical devices as he listens than when he reads. Some recognition of the multi-level situation in language would be realistic and helpful.

Long, complete courses in grammar, punctuation, or vocabulary imply the pressure "to finish the book," or "to go through the course from A to Z." Such a situation is a maximum hindrance to major advantages of programming which are capitalizing on the student's interest and staying on the subject until the skill is mastered. Of greater benefit would be a series of at least semi-independent units which might be used in any order best suited to the individual situation. Susan Markle's program in vocabulary is a helpful step in this direction. In addition, there might well be parallel units, at different grade levels, so that a given skill can be taught at the student's point of maturation.

Greater experimentation with and understanding of the "multiple-right-answer" technique seems useful in language arts. Some of these answers might well be linked into a line through such a device as "but have you also thought that maybe" to destroy the one question—one answer syndrome.

Mr. Branson: We could conceivably write a technically perfect program that would be utterly useless because the behavior established by the program would not be beneficial to the student. Granted, many technical problems have not been solved. Nevertheless, the emphasis must be placed on the specification of the objectives and the elaboration of the purpose of the program. Many people argue that poetry, literature, music and art appreciation should not be programmed. I have no argument with those who hold this position. If a programmer places a program in front of me entitled "Music Appreciation" or "Art Appreciation" and the program achieves its objectives, then, and only then, can we argue that art appreciation "should" be programmed. When someone argues that a given subject matter cannot be programmed, then it is time to say that only when material is successfully programmed will this argument be overcome.

Mr. Briggs: A branched, linear device might well be helpful so that a student could skip skills which he already knows and go at once to other skills. In an "understanding of poetry" program, it is possible to say that reading and comprehending comes at three levels: (1) understanding what the author says, (2) understanding what the author implies, and (3) being able to generalize from the specific implication. A program such as this might provide the selection to be read, followed by some questions, six or more. If the student got none right, he would do the exercises on understanding the text; if he got part right, he might go on to implication or application.

There are a number of areas in language arts which have hardly been touched by programs. Oddly enough, punctuation programs are scarce while spelling and grammar programs are fairly well represented. A word of warning might be said to teachers seeking a grammar program. The entire program should be read (worked) by the teacher before it is selected; some of the information presented is dead wrong, and in other cases, the writer of the program may use a philosophy of grammar completely unwelcome to a given teacher. There are some good programs in vocabulary, but there are none in recognizing devices of collective sanction (propaganda) or in reading for larger units of expression. There seems to be no programs in the rhetorical devices of larger units (paragraphs, essays, etc.); there is nothing in phonetics and phonemics or in most of the areas commonly covered in speech (except debate).

Mr. Branson: In summary, it appears that there are many problems in the language arts area which are the sole responsibility of subject matter specialists. It is essential that we determine the desired terminal behavior for any program in this field, then set out to achieve that behavior. Until we can arrive at mutually acceptable goals, we cannot agree on what course we should follow.

SOME PITFALLS IN THE CLASSROOM USE OF PROGRAMS

Robert K. Branson

Robert Branson cites the dilemma posed by the fact that a teacher's first use of programmed material probably will be for remedial or enrichment purposes, whereas most programs were not developed for these uses. He also cites experimental data that raise questions about the traditional view that cheating is detrimental to learning.

The purpose of this paper is to elaborate some of the problems that teachers will face as they attempt to integrate programmed materials into their classrooms. Those programs that are introduced will most likely be used as supplementary, remedial, or enrichment devices. Although programs should be effective when used in these ways, most programs have not been planned for these uses.

Consequently, the initial problem in the use of programmed materials in a classroom may well be an inappropriate application of the program. One of the more important reasons for such a situation is that there are not enough programs available to meet everyone's specific needs. There is probably little that can be done to reduce this hazard other than to suggest to program users that they attempt to match the intended use of the program with its objectives.

If, in a program on FRACTIONS, the programmer has assumed the abilties of addition, subtraction, multiplication, and division, he may then wish to proceed as quickly as possible into the manipulation of fractions, without reviewing these fundamental operations. It is true, however, that there are vast differences in the abilities of students to add, subtract, multiply, and divide. Perhaps a short test, supplied by the program maker would help the teacher determine if the student had all the prerequisites for taking the program. In the General Programmed Teaching Corporation (GPTC) testing laboratory, we have generally found that students taking programs without the correct prerequisites always have considerably more trouble than those students who are proficient prior to starting the program. An effective trial of a program cannot be assured unless all of the specified conditions called for by the program are satisfied.

Although I hesitate to mention this next point, since it has become a family skeleton in programming technology, cheating still remains a serious problem. Theory demands that students respond prior to checking the answer given in any frame. Presumably, the response should occur prior to the "reinforcement" provided by the confirmation.

During a recent program administration in a private school in Albuquerque, we encountered a wide-spread cheating problem. We were testing a program on multiplication and division in a third grade class. We first tried using programs with masks, and found that students virtually always checked the answer before responding. We then decided to provide machines for each student. The machines, Min-Max II's, were used for the duration of the program. Our reproduction paper did not work well in the machines, and our frame layout permitted the student to see the answer in some cases before actually making the response. Our director of testing and the classroom teacher were both upset by the cheating. It reflected badly on the teacher whose students were cheating so persistently and so effectively. There are a variety of ways that one can detect cheating in the use of programmed materials, but the simplest seems to be the direct observation of the subject. When the program had been completed by the students, the data were analyzed to see if any measurable effects had been demonstrated.

The first thing we discovered after administering the post-test was a substantial percentage gain for each of the students. A second rather startling fact was that there were no reliable correlation coefficients between the estimated amount of cheating and the post-test achievement score. Neither could we find any reliable correlations between intelligence and achievement test scores, pre-and post-test errors, or response errors and post-test scores. There were also no reliable differences between scores of students taking the program in the classroom, and those taking the program in the GPTC testing laboratory. The students in the laboratory were under constant surveillance in order to prevent cheating.

Although cheating seems to be a serious problem in programming (and one that is very likely to be encountered in the classroom where a teacher must monitor some twenty to forty students) with our measures of achievement, we have found no evidence which suggests that cheating is detrimental to learning. We will grant that this is a startling conclusion, and that it is only tentative; nevertheless, until we have more exhaustive data, it appears that we must re-examine our assertions about the theoretical effects of cheating.

The next situation that I would like to discuss occurred at Louisiana State University in the summer of 1961. A current and serious problem facing many universities is what to do with those students who do not have adequate background to do university work.

Some schools have failed these students while others have established elaborate remedial curricula in an attempt to raise the students to university level. Recently, there has been a trend away from the remedial classes and back toward the "sink or swim" philosophy prevalent some years ago. The mathematics department agreed to try programmed materials in an attempt to teach many otherwise good students enough about mathematics to meet departmental standards.

Two sections of a remedial mathematics class were selected and programs were purchased for those students. The students were told that as soon as they could pass the final examination, they would be allowed to enroll in a regular credit course. A monitor was provided to answer the students' questions. Although some students progressed through the program, passed the final examination, and went on to university level courses, the majority of the students did not pursue the programs actively and many of them failed the final examination. Interestingly enough, there were no significant differences in the number of students failing the final examination in the regular remedial classes and those in the programmed classes. Some students in the remedial classes finished the programs early and were then free for the remainder of the semester. One student finished in two weeks and was permitted to enroll in a regular credit course which he passed with an adequate grade.

The problem in this case seems to be one of motivation. We all know that with programmed instruction, learning can be fun. It is quite possible that these students were so far behind and had so little interest in pursuing a university degree that they made no attempt to apply themselves to the programs. It is also true that these programs were not intended to be remedial materials. And, although the programs did at least as well as regular classroom instruction, thus relieving the department of a certain financial burden, the programs did not accomplish what it was hoped that they might, which was to bring all of the students up to an acceptable university level.

This is not an indictment of programming, per se, it is merely a description of a situation in which programs were used in an attempt to accomplish results that teachers had failed to accomplish. The findings were not dramatic.

Arthur Melton once remarked that programmed instruction would never achieve its ultimate effectiveness until a complete systems analysis was made of education. When such information is available, we will know when, where, and how to integrate programs into the system. Only then can we expect to avoid large pitfalls in the uses of programmed instructional materials. Conversely, we can also see that many of our attempts to use programs have been highly successful in spite of our making errors in using them.

WHAT SERVICES TEACHERS AND EDUCATORS WANT AND NEED FROM PROGRAMMED LEARNING EXPERTS

Russell Robbins

Russell Robbins feels that programmed instruction and automated teaching devices will play an exciting and expanding role in the future. How rapid and how extensive these new methods of instruction will be implemented is not known. Because sufficient, valid, and reliable research evidence is at present unavailable, many teachers are apprehensive about the effect that programmed instruction might have on the teaching-learning process, the students, the whole school organization, and on the role of the teacher. Although the prospects for programmed learning appear promising, many questions remain to be answered.

A number of educators and others believe that programmed instruction, used with or without teaching machines, is the answer to many of the problems in education. Enthusiastic proponents of programmed-instruction write in glowing terms of the superiority of this method over methods used in schools today. Their enthusiastic viewpoints, however, are not shared by all teachers and educators. One finds a certain reluctance on the part of many to accept autoinstruction as the salvation of public education. The reluctance on the part of some teachers to accept and wholeheartedly support programmed instruction probably stems from several viewpoints.

First, although critics admit that there is some favorable research evidence to support the superiority of programmed instruction versus more conventional teaching methods in some areas of the curriculum, there is insufficient data, at this time, to draw final and valid conclusions. After reviewing research studies on automated learning one writer (Stolurow, 1962) stated:

> While there has been a history of research studies relating to automated instruction, they have only scratched the surface. Despite their number, the research studies relative to automated instruction are still limited; the resultant findings are more provocative than definitive.

Second, some teachers are reluctant to give support to programmed learning because they fear teaching machines might replace them. Proponents emphatically deny that teachers will be replaced by machines. However, one can only conjecture on this matter because the roles of teachers and administrators presently lack clear definition. In addition to fears of being replaced, some teachers also feel insecure about the whole concept of programmed learning. Their insecurity may come from a lack of knowledge of auto-instructional devices and how they will be utilized in the instructional program.

In order to allay teachers' fears and secure their support for programmed learning, it is imperative that many questions be answered regarding the role of the teacher and administrator.

Generally speaking, writers on the subject of programmed instruction are prone to touch lightly on the role of the teacher using this new medium. Pressey has stated that automatic devices would free the teacher for her most important work of developing in her pupils fine enthusiasms, clear thinking, and high ideals. (Pressey, 1926). Barlow views teaching machines as a way of implementing and increasing the teacher's instructional effectiveness. (Barlow, 1960). Much of the drudgery may be taken out of the teacher's job to the extent of eliminating much of the detail of instruction and drill. Although much of the drudgery may be eliminated, the teacher will still continue to be responsible for the pupil's instructions. The teacher will thus have more time to spend on planning for individual needs, to better master her own subject matter, and to become better acquainted with her students (Stolurow, 1962). Conjecturing on the revolution that will take place in education, Stolurow stated that high school teaching staffs will include educational analysts who will have specialized in various subjects, and who will review student records on an individual basis (Stolurow, 1962). Teachers will be assigned a minimum of routine duties. Besides constantly seeking to discover problems and needs for special attention, teachers will diagnose information and difficulties and make recommendations for improvement. The concept of the role of the teacher will be changed entirely to that of a thinker and planner. In the coming era of auto-instruction and teaching machines, Ramo (1962) sees the teacher as a type of educational specialist; a teaching engineer not only concerned with the educational process, but with the design of the machines and programming of instructional materials.

Few people doubt that the role of the teacher will change in the future because of teaching machines and other methods of auto-instruction. What these changes will be are mere speculation at this time, and this uncertainty has naturally created misgivings on the part of many teachers. Although some universities and school systems are experimenting with programmed learning and its implications for instruction, many teachers throughout the country are not well informed on the subject. Other teachers question the validity of extravagant claims made by some proponents of programmed instruction, while many others are concerned with the changes that will occur relative to their roles as teachers.

During the second semester, 1963, a group of senior student teachers from Northern Illinois University who were finishing their teacher training programs in June were asked to pose some questions concerning programmed instruction. It was assumed that their training was comparable to that received in most universities and that they were probably as well acquainted with audio-visual devices as were most new teacher training graduates.

The questions posed by the students were grouped into two general categories: (1) the effect programmed instruction might have on children and on the teaching-learning process; and (2) the effect programmed instruction might have upon the curriculum and the teacher. A large portion of the questions seemed to indicate a feeling of concern on the effect programmed instruction might have on children and the teaching-learning process. Students wondered if the emotional and social growth of pupils might not suffer by the preponderant use of such devices. Is it possible to program materials which will teach democratic values, restructure attitudes, and stimulate creativity and reflective thinking? A brief resume of the questions in this category are: (1) Will the use of teaching machines hinder emotional and social growth?; (2) Will the use of teaching machines and programmed materials hinder creativity?; (3) Can programmed learning teach values and attitudes?; (4) How can teaching machines motivate and hold childrens' interests at a high level?; (5) What happens when the novelty of working a machine wears off?; (6) To what extent will programs provide for individual interests of the child?; (7) Does programmed learning allow for reflective thinking?; (8) Does programmed learning allow for equally effective opportunities for all levels of learners?; (9) Does programmed learning permit children to discover for themselves?; (10) Can children benefit from different ideas and viewpoints of others in the room?; (11) Is it possible that the use of teaching machines might lead to rote learning rather than to meaningful learning?; and (12) How will programming affect teacher-pupil planning?

The remainder of the questions appeared to be mainly concerned with the effect programmed instruction might have on teachers and upon the curriculum Students were interested in finding answers to these additional questions: (1) Will teachers be able to develop programs themselves or will this be the job of programming specialists?; (2) If programs are developed by programming specialists, how will the objectives of individual teachers be incorporated in the program?; (3) Can all subjects taught in the elementary and secondary school curriculum be programmed? If not, what subjects do the experts believe can best be programmed?; (4) Will each teacher have the opportunity to choose the programs she will use?; (5) Will teaching manuals or guides be available with programs?; and (6) What preparation is necessary for a teacher to be able to effectively program material?

Although some of these questions may seem naive to the expert in the field of programmed instruction, many may be apropos to the classroom teacher. Questions such as these must be answered if the role the teacher will play in instruction in the future is to be clarified. There are also many problems confronting school administrators who wish to incorporate programmed materials in their schools today.

The problem of school administrators have become complex, serious, and challenging. A number of their problems have been brought about by the introduction of new media such as auto-instruction. Administrators face the same dilemma as do teachers in that many of them have had little or no training or experience with programmed instruction. How does an administrator decide what programmed materials to purchase? In a large school system where trained research personnel are available, the system can conduct its own research on automated devices and materials. This does not solve the problem in the small school district, however, where research personnel are not available. The small district administrator must obtain programmed materials from a commerical company or wait until research programs in larger school districts or universities have developed fully tested programs. If an administrator decides to purchase materials from commercial companies, he must be able to determine the merits of each program under consideration. To make a decision as to what program or programs would best fit his district's needs, the administrator should have a set of criteria for evaluating programs. Several sets of criteria have been devised, but none have yet achieved wide acceptance.

Auto-instructional advances have confronted the administrator with many other kinds of problems. How will teaching machines and programmed instruction affect the curriculum, the staff, the physical plant?

Team teaching, auto-instruction materials and equipment will undoubtedly require changes in the curriculum, in the qualifications of the staff, and in the physical plant. Scheduling patterns will change and new patterns will have to be developed. These are but a few of the problems that administrators will have to consider with the coming of auto-instruction.

A PROGRAMMED TEXT IN PROSODY

Miriam W. Hiester

An exhibit of teaching machines led Miriam Hiester to develop a three part program on prosody for use in her college English classes. In completing her successful program she found that her conventional instruction was also improved by applying the rules of good programming. She outlines a bright future for college level programs and encourages teachers to try programming.

The need for writing a programmed text on prosody emerged from the following conditions, all very familiar to the teacher of freshman college English. Few students in freshman English know the basic principles of prosody. The material given on this subject in the average textbook is very scanty. Library reference books are too detailed, too lengthy, too technical for students on this level. Presentation of the material by lecture with illustrations on the chalkboard is time-consuming and lacking in effectiveness in many respects: many students take poor notes, misspell terms, become confused; very *few* make good notes or score well on tests involving use of terms and procedures.

The way to improve this situation became apparent when I heard about programming and investigated its possibilities. At first I thought that only grammar, spelling, punctuation, and such other mechanical, right or wrong-material could be programmed. In 1960, I attended a lecture, at the University of Texas, on teaching machines and observed a machine in operation. One of the programs was an analysis of a poem by Gerard Manley Hopkins, for which they handed out mimeos. Trying out this mimeographed program on my students in the San Antonio College, I found that its measurement of their ability to analyze a poem correlated very closely with my own estimate gained by the usual means: tests and class participation. Final motivation to try writing a programmed textbook came with information gained from lectures given in the Medical Field Service School by Captain David Wark. He had specialized in programming in his graduate work and was encouraging faculty members in MFSS to investigate possibilities of using this method in the school.

The procedure I used is very simple. First, I listed the various topics of prosody and decided in what order the students could best learn them. I then broke each topic down into small parts, progressive steps. I used the linear method, placing an explanation of one small part followed by a question on page, 5 x 8½ inches; the next page contained not only the answer to the question on the preceding page, but also the next question or the next explanation and question. I did this to save space, even though I realized that some of the experts might disagree. Another deviation from recommended procedure is that I included more information on each page than is usually found in the so-called scientifically constructed commercial texts. Since these were college level students, I felt they could take larger "steps" without adverse effects.

The first part of the program contains a definition of rhythm, an explanation of stressed and unstressed syllables, names of the kinds of metrical feet and terms for lines according to number of feet. The second part consists of an explanation of rime and rime schemes and included various often-used stanza forms: couplet, tercet, quatrain, ballad, sonnet. The third part contains poetic devices: alliteration, onamatopoeia, simile, metaphor, personification, etc.

Believing that the students would learn better if they made active responses, I prepared a separate answer sheet, keyed to the questions in the text. The students responded by filling in the blanks on the answer sheet, not on the program. The separate answer sheet has two advantages: first, programs are not used up by each student, making it possible for him to go through the text as many times as he wishes; and second, the texts could be collected at the end of the course and used for another class. Most students requested one or two additional answer sheets. They were allowed as many as they needed.

Periods in the Evening Division of the San Antonio College are 3 hours with a 20 minute break near the middle. I used the last half of one period for the programmed instruction. First, I explained the purpose of the booklet, and how the students were to use it. Then I handed out the booklets and answer sheets, stressing that answers were to be recorded on answer sheets, not in the booklets.

There was a dead silence for 45 minutes; then pairs or small groups of students began discussion points. I moved among the "discussion groups" to answer questions and note progress. All students went through the booklet at least once during the period; some twice.

Assignment for the next period was to read some selected poems, from the textbook, and apply principles learned.

The programmed text has now been used with three classes. Students in all three classes were most enthusiastic and responded well. Many asked to keep the book after the final examination "for future reference." Students receiving instruction in this manner scored significantly higher on prosody portion of test than those receiving the instruction by the lecture method.

The following semester, I had some of the students in the sophomore English (Survey of English Literature) course and found that they had retained the information well. One who had not been in my freshman class requested "one of those books your other students had that taught them so much about poetry".

The programmed textbook seemed to stimulate interest in poetry itself and the interpretation of it. Two students (boys!) from separate classes wrote poems and handed them in for my appraisal.

The programmed text injected a certain amount of excitement into an otherwise routine explanation. My enthusiasm grew as I progressed in constructing the program. Some of this enthusiasm carried over to the students. In fact, a teacher *must* have a positive attitude toward a program to make it effective.

Programming this small part of a course had its effect upon other units I taught. I became more aware of step-by-step instruction progressing logically toward a desired objective. The state of mind induced by programming, a sort-of "scientific" point of view of subject matter forces a teacher to search for order in the materials themselves and place this above any personal preference or eccentricity. Many English teachers fail to see the *order* inherent in literature. You are never quite the same again after programming a course or even a very small part of it. Teaching literature becomes less a private than a professional matter.

In *College English,* January 1962, Kenneth S. Rothwell published an article entitled "Programmed Learning; a Backdoor to Empiricism in English Studies." He states,

> The full implications of teaching machines and programmed learning to the teaching of English composition and literature have not, so far as I know, been completely thought out. . . . How much or how little of English studies can effectively be programmed remains a question which only experimentation can answer, though the likelihood is that wide-scale studies may open up more possibilties than anyone can now envision. Virtually all remedial English at college level could be handled by automation. Teachers, relieved of the executioner's role, could then become counselors rather than taskmasters. Their human talents, at a time when trained talent is scarce, could be salvaged for situations better suited to them than mere frill. . . . The applicability of programming and machine teaching in problems beyond the level of simple mechanics remains an unexplored area.

Approximately 60-65 percent of programmed material is on mathematics and science; foreign language teaching comes next. Most material in English is on grammar, punctuation, spelling, vocabulary, reading comprehension, and such. In 1962, Doubleday published a Tutor Text on Modern Poetry, written by John Clark Pratt (Pratt, 1962), Instructor in the U.S. Air Force Academy, Colorado Springs. As far as I know very little has been done on programming literature. It is as though a vast new continent, just discovered, lies before you to explore.

It is now possible for a machine or a programmed text to force students into the kind of close analysis of a piece of literature which English teachers have always wanted but rarely achieved. The obvious advantage over the conventional classroom discussion method is that all students participate in all of the program. In a classroom usually a few carry the burden of the discussion.

Try programming some small portion of what you teach. Your enthusiasm will grow as you proceed; you will be surprised and delighted with results; your teaching will never be quite the same again, for there will always remain with you that scientific, logical point of view in the presentation of your material. Here is a new aid to teaching, most promising when used well. Try it!

TOP—TRYING OUT PROGRAMS

Virginia Zachert

Virginia Zachert outlines a five point evaluation effort for teachers who are interested in trying out programs. She states that programs must be helpful, meet teaching objectives, be practical and economical to use and produce statistical results similar to those being obtained from conventional instruction. She warns against over-sophistication in tryout design in a teaching situation.

This field of programmed learning is something to preach about. I am completely convinced, after almost seven years of research in this and related areas, that programmed instruction offers something that can be helpful in all types of education whether religious or secular, whether formal or informal, whether academic or military, and whether adult or non-adult. You, too, are interested in new approach to education or you wouldn't be here.

In the field of education as in the field of psychology and religion it seems that everyone is an expert. So in the field of teaching machines and programmed learning. Everyone is either "for 'em or again' 'em" often with little or no knowledge of just what is being discussed. Actually you can become an expert in this area with about 40 hours of reading because programmed instruction is so new. However, the field is moving so fast that you are obsolete if you take time to sneeze!

The most fascinating thing about this programmed instructional revolution is that now we have a way of not only checking on the student learning but of checking on our teaching. In many studies of educational techniques and the comparison of various methodology research has not shown results that were either desired or expected. The trouble with some of this is not in the experimental design but rather in the subject matter. I was trained as an experimental psychologist and it is disturbing to have to work with humans. After all, people seem to be the most cantankerous things in the world, especially students! Although programmed learning really holds great promise the "people" factor may be the reason research studies to-date haven't shown dramatic results.

Many people will tell you that the best thing for the teacher to do is "sit back and wait" until the researchers come out with more conclusive results and are able to tell just what is happening, how it is happening and what can be expected. But I say to you: Don't sit back and wait! You are the onse who know what your needs are and you are the ones who can best tell what is answering these needs. So I say to you: TOP or TRY OUT PROGRAMS.

There are five things that are going to be important as you enter into this area of experimenting or researching or evaluating. I will use the acrostic letters HOPES to help you remember the five points.

First, for the letter H, helps is your word. If programs aren't helps to you they should not be used. We look with high hopes to something that will help us to train better teachers. As you begin trying out these programs the first question will be: Does it prove helpful?

Secondly, for the letter O, I suggest that objectives be your word. Does this new method help you reach the teaching objectives you are striving for? Of course, here we may have to re-evaluate our objectives in our teaching and I think this might be good for us. What are our objectives in administering programs? Do we get objective data? How do we objectively evaluate it? So we ask: Does it prove objective?

In the third place, for the letter P, I suggest that practical be the word. In the field of research, of course, we usually can't answer this question of practicality until the end of our work. As teachers you will be interested in it from the first day. Enough work has been done on programs that are now available for purchase that you can readily see if it will fit your needs. (After all, in programmed instruction, materials must be student tested as they are being prepared.) All of this information should be listed in "Programs '62" and "Programs '63" published by the Government Printing Office. So even though you may not know the answer at the start you definitely will want to ask the question: Will it prove to be practical?

Fourthly, for the letter E, let the word be economical. One of the real problems in the field of education is that of money. With teaching machines this cost factor can be a real problem. The machines used at Keesler AFB, Mississippi, for three years to train electronic technicians were the U.S. Industries Mark I Auto Tutors. These cost a little matter of $5,000.00 each. We found these machines to be most valuable in controlling students, in keeping records of all choices, in recording time on various portions of the course, in storage capacity of over 10,000 pages per microfilm reel and finally in acting as a page turner. This last factor was not one of major importance for us. In fact, we had the material printed out in book form and administered at Keesler and found the books to be more expensive than the film. In programmed learning the machine in most school situations is not a problem of major importance at the present. For your experimenting I suggest that books or even booklets would be much more sensible. But even these are expensive. If you start writing your own programs you will find that it is most expensive in the amount of your time that it takes. In fact, the cost of several hundred dollars a page has been quoted by some of the program writing outfits. Fortunately, most of the material you will be trying out will be in published form and will sell for little more than regular texts. But we must ask: Does it prove economically feasible?

Finally, for the letter S, let me suggest statistics. People, especially psychologist, love statistics. Many people, especially professional teachers, either fear or dread statistics. But one of the things you are going to find asked most often about any study you do is: "Was there a statistically significant difference between the two methods?" or "Just what did your data show"? My suggestion to you as practicians is not to worry about any elaborate statistical design for your try-outs. After all you are now able to tell whether your students are learning adequately or not. You are able to assign grades which are still found to be the best predictors of college or graduate academic work. And I am sure you can determine to your own satisfaction whether or not the methods you try out are valuable or not, and very simple statistical techniques are the tools you use. So don't object to asking: Does it prove statistically valid?

Here then are the five key words: Helpful, objective, practical, economical, and statistical which can be remembered as we count them off on the fingers of our hand as we look with high hopes to the new field of programmed learning.

Thus the thumb would be H for helpful, the index finger O for objective, the long finger P for practical, the ring finger E for economical and the little finger as S for statistical. Now look at your own hand and let's count these off together raising each finger as we repeat the key words.

This reminds me of a story. It seems that the fingers were having an argument as to which was the most important. The index fingers says, "I'm most important, I'm used to point." The second finger says, "Don't be silly. Anyone can see that I am longer than any of the rest of you. Obviously you can see I'm most important. If a finger gets jammed its usually me." The third finger says, "No, I'm most important. I'm the ring finger that everyone looks at, especially on a good looking young girl". The little piggy says, "Everyone knows I'm most important. I can get places that nobody else can get". (At which time the little finger is inserted in the ear to clean it.) But the thumb says, "I've listened to all you have had to say and I think you are each very valuable but I think we all have strength as we work together and I consider this my most important function: to work with each of you". (With this the hand is held up and the thumb is pressed against the tip of each finger.)

So if the story is to have meaning to us perhaps I could say that all the key words are important. The first finger of objectives does point the way for us, the longer finger of practicality does stand out and often gets us in trouble, the ring finger of economics does draw attention to itself and certainly the little piggy of statistics can get facts that nothing else can uncover. But I think we would all agree that the thumb for being helpful is really the major key to our TRYING OUT PROGRAMS. We want helpful objectives, we must have helpful and practical material, we must help to keep it economical and within our budget, and the statistics must be helpful to our evaluation of what we have found out.

Yes, this has been a TOP talk. And if you forget everything I have said don't forget that only you can truly evaluate the value of programmed learning in your own teaching situation so as a professional researcher I challenge you as professional teachers to "come on in, the water's fine". You start trying out programs and give us the information we need for further research.

V. The Exceptional Student

PROGRAMMED INSTRUCTION AND THE EXCEPTIONAL CHILD

Willard Abraham

Willard Abraham briefly summarizes current knowledge and misconceptions about the exceptional child. He points out several advantages of programmed instruction in meeting their specialized educational needs. However, there is a plentiful array of problems generated by this methodology. Some of the problems are generated by well-meaning people who try to sell programmed instruction as a panacea for the problems of the exceptional child.

Until two years ago, I was more in my element talking about the two extremes on the intellectual scale, the gifted and the mentally retarded, and their education. However, these two years have provided intensive experience in a relatively new interest of the preparation of programmed materials, a subject with almost infinite potentialities for contributions to the broad area of education.

One cannot be even remotely connected with the challenges of this field without recognizing some vital areas in which it will be felt with increasing intensity. The implications it has for *all* children are great, and those who give only lip service to the "all" factor and then promptly begin to make exceptions lose the point of its real potency. It can help do a better job of teaching than even our best teachers currently do, for it stresses the importance of the teacher as the core of the learning situation in this era of the knowledge explosion.

It has a new, experimental, open-the-door, anti-status-quo lilt to it that in its vigorous way will ultimately bury the poor programs, inadequate and fakey testing, false claims, and sales pitches that temporarily threaten this basically strong, thriving infant. It has a glamor quality that attracts dilettantes and a revolutionary air that entices non-conformists from the fields of psychology and business—but it is important in its own right as a vital force in our schools, industries, military installations, and homes. It needs neither the rash and foolish statements that have tended to mar its auspicious birth nor the promoters who make them. Nor does it warrant the side-long glances of wonder prompted by a few of the slightly addled personalities that lend a little unnecessary color to a basically sound, thriving technique of teaching.

Before we seek the implications of programmed instruction for exceptional children, let's stop for a few moments at the focal point of those children who deviate enough from the so-called normal to need some special educational assistance. As we discuss them you can be thinking (on the basis of what you know of the field of programming) of how programmed materials can help them perform closer to their capacities.

HOW MANY OF THEM ARE THERE?

WHO ARE THEY?

WHAT DO WE KNOW ABOUT THEM?

The answers here will have to be brief but direct, to-the-point, and indicative of the importance of the subject.

We have given more than enough time to the clichés of education. It is refreshing that in one part of it words like the ones I'll now use have meanings that are realistic—"individual differences", "the whole child", "the needs, interests, and abilities of children", "take the child where he is". The unfortunate point is that such words and phrases have sometimes been uttered almost indiscriminately, without real meaning, except in the area of special education where we attempt to talk in definite, meaningful terms about "children who differ".

The action needed is for a proportionately large number of children, approximately one in eight of our school-age population. If that number seems small to you, look at it this way: With the average size family in the United States consisting of three children, one out of your family plus the neighbors on either side of you will be "exceptional"—and don't count on his being gifted! If that statistic doesn't work out, there will be two exceptional children in the next group of three families and one will be in each group of eight or nine grandchildren stemming from each pair of grandparents, or two in the next group of grandchildren.

The mentally retarded, sight handicapped, speech handicapped, hearing handicapped, emotionally disturbed, orthopedically handicapped, and gifted, a group of frequently overlapping rather than discrete categories, are among those under consideration. Their numbers and problems have received increasing attention and understanding in recent years through women's magazines, the concern of the late President Kennedy and his family, popular books (such as Pearl Buck's

The Child Who Never Grew and Dale Evans Rogers' *Angel Unaware*), motion pictures (such as *A Light in the Piazza* based on the New Yorker novella by Elizabeth Spencer and *A Child Is Waiting*), and the dedicated professional people whose contributions bear little relationship to the limited financial returns they derive from the services they perform. But the neglect of these students continues in many localities and states.

They represent tragic areas of false information and mis-information like these: (1) mentally retarded children are delivered to those who sin or to families invariably tainted with at least a trace of retardation; (2) there is always a close relationship between intellectual limitations and the areas of mental illness, epilepsy, cerebral palsy, and brain injury; (3) "slow learners" always have low IQ's. The truth is far removed from such statements: (1) mentally retarded children *can* be and *are* born into families in every race, religion, nationality, background and socio-economic category; (2) there is no *necessary* relationship between mental retardation and the four groups listed above; (3) gifted children who perform below their capacities are literally "slow learners" of a type, and "average" children operating at a lower level are *pseudo* slow learners.

Among the more neglected of the exceptional child categories (despite the increased conversation about it) is that of the gifted. With half of the top quarter of our high school graduates reportedly not finishing college, with many teachers feeling either uncomfortable or threatened by their classroom presence, with the foolish tag of "undemocratic" or "elite" still occasionally attached to special educational programs for them (although *not* for the football team, art class, band, or choir); the progress of our bright students still lags behind our need for their insights, potential knowledge and creativity.

The 19th century feeling that they "ripen early and rot early" has long been laid to rest by the Terman study and others which indicate not only that *as a group* they are above average in all measurable traits but also that they generally retain their giftedness into adulthood. No longer can we be satisfied if they work up to grade level when they're capable of more, or depend on their "muddling through" school when figures show that too many drop along the educational wayside. No longer can we afford to be bogged down in definitions of who they are (IQ and/or talent and/or creativity), how to identify them, or what the terminology means (enrichment versus acceleration versus segregation, or heterogenious versus homogeneous grouping). No longer can we endure the talent wastage of bright girls ("she'll *only* be a wife . . . or mother"), of children from lower socio-economic groups, different cultures, or rural areas, of handicapped children who also happen to be bright and perhaps difficult to identify as such because of their handicaps, of drop-outs whose finances, emotions, aspirations, or family conflicts deprive them and us of their promise, of brilliance being rubbed down to mediocrity because of our neglect.

Another problem area, already referred to briefly, is the "pseudo retarded"; the ones who are not really slow but who test out or appear to be at the retardation level. The reasons are many and the solutions are not easy to develop. Among the causes are a different language or culture, financial depravation, invalid testing, physical handicaps, or (although we dislike admitting it) poor teaching. Programmed instruction can certainly fit into this picture.

The educational trends for these children and their implications for programmed instruction are fast-moving, vibrant currents on the school scene. For example, more than half of the fully blind children of school age are in regular public school classes (with specialist "resource teachers" helping the regular teachers). The discussion of so-called sign language versus lip reading and speech for deaf children seems to be edging firmly toward the latter. Cerebral palsied children are now more frequently recognized as being part of the normal range of intelligence, although the *average* IQ for a large group of CP children chosen at random will be considerably below such figures. Terminology in the area of the mentally retarded has long ago left the moron-imbecile-idiot morass and settled into the more platable educable-trainable-custodial or mildly retarded-moderately retarded-severally retarded camps.

Research in these areas is also making fantastic leaps of progress—with causes and correction for PKU (phelketonuria) and retrolental fibroplasia (blindness of premature babies) as forerunners of other dramatic breakthroughs. The awareness of and programs for the gifted, an increase in state aid to help support programs more adequately in all of these fields, and the cooperative, unselfish approach of professional disciplines to solve educational, medical, psychological, and related problems are all affirmative signs which point toward more progress in the years ahead.

As we turn our attention to the programming side and seek implications and relationships between programmed instruction and exceptional children, some vital points immediately come to our attention.

In his remarks in his presidential address, Colonel Ofiesh put the issue in proper perspective when he said that through the use of this technique we "see children learn who otherwise would not have learned" and are able to "remove frustrating, devastating aspects of failure to learn". In a report at the NSPI Convention pertaining to mentally retarded children, Dr. F. C. Williams of the University of South Florida stated that hours could replace years in the area of word recognition; he also pointed out another unique development—materials prepared for use with the mentally retarded are being transferred to the education of the so-called normal, instead of the usual reverse pattern. Nowhere on the education scene is there more need for curricular materials based on small steps, sound reinforcement, and success than with the mentally retarded. No children have been so frustrated as they, so hurt, and ignored as they frequently are in the years before many of them get the special attention they need. Whether in regular classroom settings in isolated areas or in special education classrooms with skilled, well-prepared teachers; programmed materials prepared specifically for them and thoroughly tested on similar children can provide an educational breakthrough in this country.

But there are problems. One is based on the tendency of many of us, and not just educators, by any means, to go off on national binges. We did it with prohibition, with the near-hysteria we sometimes display toward movie stars, with our wild swings of the pendulum in clothing, food, and status symbols of all kinds. Martin Luther once said that humanity is like a drunken peasant who is always ready to fall from his horse on one side or the other. With cautious professional preparation, testing, and research in programming perhaps the danger of using programmed materials as a panacea can be lessened.

Some of our more enthusiastic and less careful friends in this field can cause us the most difficulty. It's the old line that your enemies won't hurt you, you just need protection from your friends. A few years ago, Jacques Barzun wrote an article called "Cults of Research and Creativity" (*Harper*, October, 1960) in which he warned about mixing labels with real content. Our danger signs are related to his warnings as we tend to fall into a semantics mire. Too frequently some of our psychologists who are attempting to call the shots on programs and programming for school purposes are not school-oriented. Too often their lack of realism stems from the fact that their knowledge of children, child development, teachers, school practices and problems, and administrative and financial issues is limited. Hiding behind terminology they arouse questions that are inappropriate and doubts that are unnecessary.

Communication is for the purpose of sharing ideas and not for impressing people with one's scholarliness. In both education and psychology we too often forget that simple objective as we deliberately mislead our publics with esoteric dogma. Some years ago Henry M. Wriston, former President of Brown University, demonstrated the obstructionist quality of language. He converted the song "Getting to Know You" (from *The King and I*) from its concise, monosyllabic clarity to this: "Motivated by empathy, Anna was restructuring empirically her approach to the technique of cross-cultural communication at a meaningful level with purposive intent. She undertook this in a relevant context of indigenous habitation."

An incident that occurred recently demonstrates a related issue. One of the top administrators in a large publishing firm, whose name you would recognize, said after a productive conversation regarding programs we might prepare for them, "I hope you don't have any of those sandalled—bearded fellows working for you". True or not, important or not, warranted or not, his inquiry is based on both truth and importance for *him,* and he constitutes a strong link in the programming future.

Our objective whether we are talking about programmed instruction for exceptional children, or other children, or industry, the military, or home improvement is to make a contribution, not create a cult, to be practical and not obscure, to help solve the plentiful problems we can identify related to learning and not to add to them.

We face a plentiful array of other problems, such as: (a) teachers who are misled into thinking that they (or almost anyone) can write a program "that works", (b) teachers encouraged to evaluate programs without proper guidlines for doing so, (c) limited field testing (as important as such evaluative procedures can be if done well) that is put forward as a substitute for the far more necessary controlled prepublication testing, (d) the lack of realization that a minimal level of aptitude and ability are needed before a program can be used effectively, (e) the false assumption that a program developed for the so-called "typical" child will automatically work with exceptional children ("just use it with older mentally retarded or younger gifted or braille it or . . ."), and (f) the school problems of budget, fear of what's new, apathy, or "what will I do with children who finish more quickly than others?"

Programmed instruction can give real meaning to practices related to "acceleration" and "enrichment" often glibly referred to among gifted child educational plans. It can increase individual differences as it encourages children to move at their own rates and into new areas of knowledge and wisdom. It can help restore the battered-down confidence and help reduce the accumulated frustrations of our "slow learners" and retarded.

"A man's reach should exceed his grasp, or what's a Heaven for?", said Robert Browning, and the advice is sound for those of us who fully appreciate the contribution we can make in a very concrete way to specific children. "A teacher can never better distinguish himself in his work than by encouraging a clever pupil", said Carolus Linnaeus, "for the true discoverers are among them, as comets amongst the stars", and we begin to recognize that this new approach to learning fits right into that teacher's hands. From an unusual source comes the final bit of encouragement. In a book introduction, Danny Kaye could have added "education" to the sequence when he wrote that "you can't bring health and happiness to a million children by signing a paper or waving a wand. It has to be done child by child". He might very well have been talking about programmed instruction and exceptional children, as the technique and recipient of the child-by-child route to educational accomplishment.

There is a shortage of sound programs and especially for the exceptional. There is currently only a limited number of teachers who know how to use programs wisely and especially with the exceptional. There are still few school administrators who recognize the full value of programmed materials and especially for the exceptional. All of the problems related to production, testing, distribution, public relations, and acceptance apply in intensified form to the children who still remain on the fringes of our educational concern in many parts of the country.

THE DRAPER EXPERIMENT: A PROGRAMMED LEARNING PROJECT

John M. McKee

John McKee describes an experimental project in education and rehabilitation at Draper Correctional Center, a prison for youthful offenders in Alabama. The new educational technology of programmed learning is employed with 125 inmates in a Self-Instructional School. The primary aims of the project are: (1) to develop a low cost self-instructional program that will incorporate into its operation all educational, vocational and rehabilitation training; (2) to design, develop, and utilize a self-instructional curriculum more applicable to the educational, occupational, and social needs of men in a prison society, both with respect to that society and the one they will be preparing to enter outside; (3) to evaluate the program both with respect to performance in prison and following release; and (4) to prepare a useful and adequate "blueprint" that can be adopted by correctional and other institutions.

This is a story about a dramatic application of Programmed Instruction to a special area—a prison for youthful offenders at the Draper Correctional Center of Elmore, Alabama. To my knowledge, we operate the only full-time self-instructional school in the nation.

The Draper Experiment was proposed to the Alabama Board of Corrections as a reasonable approach to the rehabilitation of inmates by Watkins and McKee (1960). The project was approved and it was initiated on 15 March 1961. The purposes of this project in education and rehabilitation were (1) to demonstrate the administrative feasibility of an entirely self-instructional education program within Draper—evidenced by an ongoing project, the ease with which we could interest and teach the inmate students, and the degree to which institutional resources could be used; and (2) to make a tentative analysis of the subject matters and skills most practical to teach inmates from the standpoint of obtaining the most productivity at the least cost.

It should be made clear that at the outset we related educational and vocational achievement of the Draper inmate to his rehabilitation, both inside and out of prison. We made the assumption that positive and significant educational and training accomplishment is a factor important to the modification of his behavior and attitudes. The institutionalized "first-offender" typically comes from a lower class background, the pressures of which evidence themselves with an inability to tolerate the actual role of student. This is sufficient in many cases to retard or eliminate desired educational development; nevertheless, intellectual and educational development is a need expressed by most inmates. There is, then, a discrepancy between expressed wishes for educational status and actual achievement in the middle class learning situations found both inside and outside the prisons. Thus, the inmate, although isolated from the main stream of society, agrees, in principle, with the value placed upon education and training as a fundamental requirement for successful living. But the inmate lacks the psychological equipment to instrument his motive. Furthermore, a good case can be made for relating the process of academic education and job preparation training to recidivism in the young offender and for demonstrating how new techniques of education hold promise for contributing to the goal of recidivism reduction.

The project was begun with 25 inmate volunteers approved by the Warden. The Warden's principal criterion of selection was that subjects could achieve, in his judgment, at a high school level. A significant number of "troublemakers" were purposely chosen for the group in order to assess any potential effect on this type of prisoner within the institution.

The demonstration project had been proposed by the Division of Mental Hygiene of the Alabama State Health Department, to the Alabama Prison System. The major cost of the first three months of operation was borne by the Alabama Prison System, which contracted with Educational Design of Alabama to assist with this phase of the project. During its first year of operation the project received continuing support from the Prison System, the Division of Mental Hygiene and from two grants from private foundations.

From the pilot project that ran for a year, McKee and Slack (1961) made a number of interesting discoveries:

1. Self-instructional programs can be successfully used with confined young offenders. The success of self-instructional programs with delinquents is remarkable, considering the almost complete lack of success of other types of material with this population. Yet, from a strictly behavior theory standpoint, it is not difficult to understand. Individuals who have a history of repeated failure in normal classrooms have been continually deprived of that certain reinforcer which we call "success." They are rarely if ever right in the answers they give on tests to teachers' questions, homework assignments, and quizzes. In some cases this reaches the point of extinction on all formal learning

tasks and even on attendance at such tasks, resulting in truancy and drop-outs. Here is a population of men, with an average age of 22, who have repeatedly failed in whatever they undertake. They failed in their homes (or the homes failed them!), in their neighborhoods, in school, on jobs; in fact, they have even failed in crime, or why else would they be in prison! While going through a self-instructional program, on the other hand, the average student finds his answers correct more than 90 per cent of the time. Such success is indeed enough to maintain behavior relevant to progressing through the materials for periods of time longer than would be anticipated with "brighter" and more successful students.

2. Another finding of the pilot project was that the experimenter-subject role relationship, wherein the subject is a cooperative research partner in a new venture rather than a more or less passive student, appears to be the best role-vehicle for maintaining task-relevant behavior. The Draper Project has been largely inmate administered, inmate managed, and inmate supervised. Such a system which gives the inmate maximum responsibility, status, and self-determination appears to be markedly superior to alternative conventional student roles which contain previous negative associations. The Draper inmates seem enthusiastic over the prospect of serving as subjects in a unique experiment in which they are fully involved and are the chief determiners of the outcome.

3. A very interesting phenomenon developed early in the experimental group; the intellectual interests of the subjects expanded very rapidly, and they were maintained at a high level of intensity. Most of these interests were noted by the experimenters and were reinforced as quickly as possible by obtaining books for them to read and by securing certain resource materials which were not readily available, such as dictionaries and technical books. The warden has stated on several occasions that this dramatic mushrooming of interests stands in marked contrast to attitudes of the inmates prior to the initiation of the project. For example, it was also noted that large numbers of the inmates expressed a keen interest in obtaining a college degree, whereas earlier many frankly admitted that they had not the slightest interest in pursuing an advanced education.

4. It is very likely that prisoners can produce self-instructional programs themselves. After a few weeks of taking the courses, several inmates started writing them. Some of the inmates are highly intelligent individuals and have attained a great deal of skill in program writing. Besides, they seem to have the perseverance that is essential for this task; and, as they state it, they have "plenty of time" in which to do it.

5. Inmate interest in serving in the Armed Forces could be an important factor in the rehabilitation chain, provided these men become more generally accepted by Selective Service. Sixty-seven per cent of the subjects expressed a desire to serve in the Armed Forces or clear up a bad record that was made in military service.

6. There are a great number of significant reinforcing factors operating in such a project, and it would seem desirable for the professional staff and the warden to be in full control of them. A very important factor is the type of feedback the subject receives as he progresses through a course. Very few programs have accompanying tests, so inmates can only guess at their progress. Some of the experimental subjects are developing tests themselves for the various courses. Certainly, pre- and post-test procedures should be induced as quickly as possible—not only for better feedback to the inmate, but also for the evaluation of the project itself.

In May, 1962, the Draper Project received a three-year grant from the National Institute of Mental Health to conduct a more extensive education and rehabilitation program.

AIMS OF PRESENT PHASE OF PROJECT. Unlike other research investigations into the use of new techniques in education and rehabilitation, the primary aim of this project is to develop a set of procedures for establishing and operating an administratively feasible self-instructional school in a correctional center. Thus, a major result of the project will be a "blueprint" report series for use by institutions who may wish to take advantage of the modern technology at low cost. Sub-goals are: (1) to design a self-instructional curriculum more applicable to the educational, occupational, and social needs of men in a prison society, both with respect to that society and the one they are preparing to enter outside; (2) to integrate useful social experiences with the specific training; (3) to develop a systematic and extensive coordination of such a project with local school boards and with other local and state agencies, to capitalize upon these relationships by investigating more thoroughly, experimenting with ways of developing positive attitudes toward self-instruction and generalizing that attitude to other more traditional rehabilitation procedures; (4) to study both intrinsic and extrinsic reinforcement factors to determine how best to maintain inmate motivation at an optimal level; and (5) to evaluate the effectiveness of the program by following up released offenders.

The inmate population has so far been highly motivated by the fact that their performance in the self-instructional programs is needed in the evaluation of these programs; and they are to some degree pioneers in a new technological development which is having great impact on public education, industry and the Armed Forces. Both student and staff have come to realize that this population is for many purposes an ideal testing ground for new programs as they are developed—not in the sense that it is representative, but in the sense that it presents in a controllable situation a wide range of educational rehabilitation problems.

Self-instructional techniques and other recent developments in educational technology have some specific features which are unique and valuable. For example: (1) the immediate knowledge of results obtained from all self-instructional programs appeals to the need for immediate gratification in the inmate population, as does the high rate of success inherent in linear or Skinner-type programs, Crowder's intrinsic programs, and Gilbert's mathematical lessons; (2) the minimum use of teachers and the role change from student to experimental subject cuts through the existing class educational barrier and provides for "Hawthorne Effect" benefits; (3) machines have been shown to have a motivating effect on populations (military) which are not dissimilar to the adolescent inmate population both in regard to individual and group factors; (4) lack of competition, absence of embarrassing disclosure of ignorance, and the self-pacing features of self-instructional techniques have been demonstrated to be decided advantages with apparently unmotivated or recalcitrant individuals; and (5) another important incentive from the inmate point of view is the fact that during confinement he can make up lost educational attainment, in many cases learning exotic subject matter (e.g., the German language) not generally achieved by those with less time to spend.

SIGNIFICANCE. The adult delinquent is largely *cut off from normal routes to achievement*, and one very important factor in his virtual unemployability in our technological society. Through a specific course of trade and academic education that can be practically individualized to his specific needs, largely because of the economy of the self-instructional method; we believe that we can secure these accomplishments: (1) put into the young adult delinquent's hands specific instruments for occupational and school achievement he will need outside the institution; (2) add appreciably to his self-enhancement, insofar as such develops out of the experience of achievement; (3) add appreciably to his motivation for more normal social adjustment, insofar as the behaviors of such an adjustment will come to appear to him as valid instruments for attaining normal goals; and (4) supply him with more intrinsically interesting self-development activities; permitting us to arrive at a greatly improved prescription for creating a positive institutional attitude on the part of the inmate and thus relieving the prison of a heavy administrative burden. Our previous work in this area gives us confidence that these things can be accomplished.

Recognizing that a well-planned program of dissemination of results is important in an activity of this nature, we plan to: (1) make available information on the administration, cost, and expected results of such a program in a prison to public schools, mental hospitals, TB sanitoria, etc., who might find ancillary value in it; (2) make available guidelines and ways to obtain the cooperation of public schools and colleges in an educational venture of this sort; (3) make available instructional programs developed at Draper; and (4) act as a testing group or "proving ground" for newly developed programs.

RECENT PROGRESS. Although the Draper Experimental Project in Education and Rehabilitation has been under way since 15 March 1961, it was not on a full-time professionally staffed basis until 1 May 1962, when a grant from the NIMH was received. This made possible the full-time appointment of both the Project Director, Dr. John M. McKee, formerly Director of the Mental Hygiene Division of the Alabama State Department of Health, and the Vocational Specialist (electronics), Norman Ussery.

The flow of students into the Self-Instructional School (as it is now called) rose rapidly and soon was more than doubled. In addition to the self-instructional group, for which the courses are primarily at high school level, the elementary classes are now located in the new school area. This new group, which has inmate instructors, is called the Junior Division of the newly created Self-Instructional School, and the completely self-instructional group has been named the Senior Division.

One of the first moves to upgrade and improve the Junior Division was to introduce all the programmed courses available. It is anticipated that within a few months many more of the courses will be taught on a self-instructional basis. However, the teaching of illiterates to read and write is a problem to which programmed learning has not yet made any significant contributions. The Laubach method, we discovered, is a very effective instrument for literacy education of prisoners. A corps of inmate instructors has been trained in the use of the Laubach method. These instructors are teaching fellow inmates with excellent results.

With the large increase in student body and the availability of many new programmed courses, it was immediately apparent that more space was required. By December 1962, an additional adjacent area was obtained and converted into classrooms. One of the new rooms was made into a large language arts laboratory, where the students in the Senior Division learn English, reading, speed reading, foreign languages, and vocabulary development. Each student is required to spend at least two hours a day in the laboratory. This phase of the School's program is managed by two inmates assigned one-half day each. A total of 70 inmates flow daily through this lab.

Although programmed materials prepared for self-instructional use are becoming available on a wider variety of subjects, as well as at different grade levels, it was found when evaluation of these programs was undertaken, that most of them had no pre- or post-test examinations. Thus, it was necessary to develop such instruments. Now there are no programs in the school for which we do not have examinations.

During the past year the Draper Project has received national recognition, and this has brought a large increase in the number of visitors from all over the nation, as well as from Alabama.

The project is committed to programming the various vocational trade areas taught at Draper. The field of electricity and electronics was chosen as the first to be programmed. To date the following areas have been developed:

Course Title	*Number of Frames*
Basic Electricity	
Introduction	500
D.C. & Ohm's Law	600
Meters	500
Batteries	490
Magnetism	750
Alt. Current	800
Motors & Generators	650
Basic Electronics	
Resistors	400
Transistors	800
Mathematics for Technicians	
Automotive	500
Carpenters	500
Electricians	800
Radio & TV Repair	Self-instructional workbooks (4)
Residential, Commericial & Industrial Wiring	Self-instructional Lab Manuals

These courses were programmed in their entirety at Draper, utilizing a corps of inmate programmers trained in programming techniques and supervised by Norman Ussery, the Project's specialist in electronics. After a man completes his basic electricity training—both theory and lab work—he is assigned to an electrician's squad. As a member of this squad he has assignments in wiring, installing electrical circuits, and trouble shooting throughout the prison. Before release the student is aided in getting a job as an electrician's helper in the city to which he is released. To date, two of the graduates of this program have been released and are now employed as electrician's helpers.

Another vocational area in which programming is being done is mechanical drafting. A mechanical drawing and blueprint reading course is being taught by an inmate expert in this field. This subject is provided primarily for the electricians who must have this skill as part of their training. When completed, this course will be self-instructional but will require a laboratory supervisor. Finally, a short course called "Signed Numbers" has been completed.

Since the project is almost entirely dependent upon the inmate for all types of services that the School requires, whether instructional, clerical, or programming; it has been necessary to develop a corps of inmates to perform these functions. Thus came into being the School's "Service Corps" comprised of 25 men. Each member of the Corps, in addition to performing his service functions for one-half day, is required to spend the remainder of his time in the School as a student. The responsibilities of the Corps members are:

Type of Service	*Number Assigned*
Clerk	3
Instructor	5
Programmer	6
Subject-matter Counselor	8
Librarian	2
Lab Technicians	4

One of the key and unique Service Corps members is the subject-matter counselor. This person serves in one of four areas: math, language arts, science, or electricity. Usually, two men are assigned to each area. The language arts counselors, for example, manage the language lab and direct or assist all the students that flow through that room during the day. They keep progress charts on the student, determine when he is ready to take a test in a particular course and put to use the curriculum of the labs. The subject-matter counselors are frequently called upon to construct tests in the various courses of their specialty area. Finally, the student must obtain the counselor's approval before he is allowed to take a final test. The counselor must be confident of the student's making the passing grade of 85 per cent, for the counselor is held responsible for the student's failure.

The counselor is developed into a subject-matter expert before he is selected or placed in this capacity. The mathematics counselor, for example, must have completed the entire high school mathematics curriculum and a number of advanced courses before he is considered an expert and given his job. He must show unusual interest and ability in mathematics, and be well liked and respected by the other inmates. Further, he must be willing to give half of his time to helping others. Similar requirements are demanded of counselors in other areas.

The subject-matter expert is also the chief test constructor. Since many of the courses that are commercially available do not have tests made up for students, and because students need and demand testing feedback, it has been necessary to develop over 100 tests. All tests are reviewed and edited by the project staff before they are approved for classroom use. Since some of the courses—particularly electricity, algebra, and plane geometry—are very long, it was discovered early that the student and counselor need more frequent feedback to be assured that the student does not have blind spots and to be assured of passing the final test with 85 per cent correct response. Therefore, the longer courses now may have 15 or 20 subtests (measuring *acquirement* rather than *accomplishment*, the latter being the function of the final exam). After the student takes a subtest the counselor reviews all mistakes with the student and teaches him the material he must learn to attain perfection; or the counselor may direct the student back over a certain part of the course that he did not master well. After the student has satisfied the counselor, he is given permission to continue through the next group of frames.

Not all test construction men are counselors, however. A few exceptional and advanced students are asked to construct tests, which they very willing do because of the prestige associated with the task and their desire to improve the School.

The Service Corps, to be sure, commands the highest status in the School. Its membership is chosen on the basis of competence, and all know this and respect the Corps for it. The counselor and instructor, for example, discuss and evaluate frequently the students under their direction with a "free-man"—something rarely done in prisons. Ordinarily, this would be called "putting a man down" or "ratting" But not so in the School. The reason for its acceptance, far from being mysterious (though visitors from other prisons continue to be amazed!), rests in the one central demand placed on the student—or counselor for that matter—namely, that he develop competence. Nothing else will do. Any evaluation made of him, from learning problems to behavior problems, is objectively and rationally approached. It is not a matter of moral training *per se* (though education in responsibility may be taking place), nor of "good" behavior, nor of general conformity from fear of authority. *Only productivity and development will suffice!*

Managing the intellectual productivity of over 125 prisoners by only two "free-men" from 7:00 A.M. to 4:00 P.M., is a complicated task indeed; however, the procedures that have been developed for control of productivity, though elaborate, are entirely functional and yield results of a gratifying sort.

First of all, no difficulty is experienced in recruiting students for two principal reasons: (1) assignment to the School carries prestige and students like it; and (2) many of the other assignments at Draper require strenuous labor and are both monotonous and unpleasant, especially farm work. So, all students are volunteers.

But once the new student enters School there is no assurance he will work consistently. The novelty of programmed learning has long since worn off at Draper, though we remain certain this format of subject-matter presentation is far superior for our purposes. Even though we are convinced that programmed material, with its so-called intrinsic reinforcing quality, has definite limitations in motivating students (for example, through five volumes of TEMAC Algebra), we can say that the programmed format still holds interest in the student who has completed literally thousands and thousands of frames. In fact, the advanced student in self-instruction will rarely study a subject in conventional texts. He reports that doing so "wastes time" or is "dull", particularly when a programmed text in the subject is available.

When the new student enters school, he undergoes an orientation. He is told by a member of the Service Corps, one of the School's orientors, what he can expect and what is expected of him. (This orientation procedure is now being recorded and will soon be programmed.) Next, he is interviewed by the Project Director or his assistant, who determines the exact evaluation tests that should be administered to the new enrollee. All entering are required to take both an academic achievement test and a vocational interest test. From interview and objective data an individual "diagnosis" is arrived at. Then a "prescription" is prepared, which details his initial course of study. This will include in all cases training in language arts and math, but a student's overall personal-social rehabilitation needs are considered and other training steps are planned.

For the Senior Division, a typical assignment on the new student's Course Data Sheet is as follows: Reading (SRA), Spelling (Sterling), English 2600, Vocabulary

Development (Coronet, SRA), 7th Grade Math (TEMAC). The student requires constant evaluation and review of his progress, rather than direct supervision. This is accomplished by the counselor's frequent contacts with him and with the Project Director or his assistant. The student himself is given a "progress plotter" for each course. This plotter has a "par angle" that he must stay within—this angle having been determined empirically for each course. If the student falls below minimum slope, the counselor moves in to discover why. Perhaps the rate is slow because of a reading difficulty. If so, special concentration is made in this area. If he has momentarily slacked off in his work, the counselor spends more time with him; and the professional staff will give him more attention which is sometimes all that is needed in the first place.

Rehabilitation Efforts. Rehabilitation is a term with many different meanings, but in the field of corrections it can only refer to a significant reduction in recidivism. No other meaning carries as much weight with the public which must foot the bill for the law enforcement agencies, courts, and prisons.

So it is that all factors relevant to a prison's rehabilitation program are viewed from the standpoint of their contribution to recidivism reduction. Some important factors include: custody, physical plant of prison, business management of the institution, prison personnel, specific correctional education, as well as vocational and general education.

This project, from its inception, has accepted the principle that it is a part of and deals with the total prison complex. The project's chief contribution to date has been a unique approach to general education and vocational training. The enormous implications are, of course, obvious to a man who has failed in everything—even in crime! The very rapid development of useful skills and knowledge, which the project in this short time has already effectively demonstrated, has radically changed many prisoners. The program holds significance for ego enhancement, as well as development of an appreciation for intellectual competence, both of these being a deeply rewarding success experience so long denied the typical prisoner. And this whole change can now be engineered and directed surely and quickly by self-instruction. For example, a total of 22 self-instructional students have retaken the California Achievement Test and have registered a gain of three grades. The total time of association in the program was only 5.5 months. Should this increase hold up for others, the project will have demonstrated the effectiveness of programmed learning for at least very significant advances in grade level achievement over amazingly short periods of time.

At the same time, this project is committed to education that has specific implications for "correction," or desirable behavioral change. It is a reasonable assumption that the following skills are very relevant to the repertoire of a rehabilitated person: personal grooming and etiquette, personal responsibility for one's behavior, good posture, correct spoken English, more socially acceptable attitudes towards the opposite sex, managing a personal or family budget, and holding a successful job interview. We refer to these training areas as "adjunctive behavior skills". They are adjunctive to the two major commitments of the project—general education and vocational training; but in another sense they may be critical to the rehabilitation picture. Take for example the matter of good speech: It is reasonable to hold that the ex-prisoner who desires to "go straight" will be immensely aided by having his subject and verb agree, avoiding slang, clearly enunciating syllables, and developing oral automatisms in correct speech.

Realizing the high value of this particular adjunctive behavior skill, the Project Director initiated an experimental class in spoken English which meets one hour daily. This class has six inmates serving as student subjects. The purpose of the study is to discover the content for a course designed to modify incorrect speech and the techniques to bring about this modification quickly. It is anticipated that a programmed course will soon be developed from the experiences of this pilot class.

Future Plans. Now that many of the mechanics of establishing and operating a self-instructional school have been worked out, the project will address itself more to specific rehabilitation areas, such as social skills, attitude changes, etc. Along this line, plans are being made to accomplish the following during the next twelve months:

1. Program a basic course in spoken English that will significantly modify the speech habits of the youthful offender in a relatively short period of time;
2. Program the eight parts of speech;
3. Put in final form self-instructional courses developed at Draper in "Personal Grooming and Etiquette" and "Rules and Regulations of Parole";
4. Develop other needed courses, such as interviewing for a job, the "Convict Culture", a programmed orientation to Draper, and a course in "How to Stay Out of Trouble".

Great strides have been made since May 1962 to improve the curriculum of the School. During the next twelve months, a four-step program will be taken to boost further the course content of the School:

1. A more balanced education will be developed by the introduction of new courses in literature and history. A science lab will be constructed to house already

purchased equipment and courses now taught in various science fields.

2. There will be an increased use of the Laubach method of literacy training, and explorations into the other approaches to the problem of illiteracy.

3. A survey study of the literacy problem at Draper will be conducted by two graduate psychology students at Auburn University, who will incorporate their findings in Master's theses.

4. Programming in the general field of electricity and electronics will continue until the entire trade area is completed. A basic course in mechanical and architectural drafting for electricians will be programmed.

We have related educational and vocational achievement of the typical inmate as a necessary adjunct to his rehabilitation, both inside and out of prison. We have described the prisoner as having a history of repeated failures in life, observing that he functions generally on a success deprivation schedule. We propose to intercede his life space with significant success experiences in critical areas—academic, vocational, and social. Programmed learning is the principle for this skill training.

We have suggested that an adequate rehabilitation program (the end product of which is a significant reduction in recidivism) requires not only specific training in the above areas, but also a vigorous, intelligently conceived, and adequately funded follow-up program. An inmate who has participated in our program for a number of months will possess a certain amount of momentum to succeed in free society. He will have optimism and drive that should carry him along over the initial adjustment period. This outlook should be reinforced by concerted community planning and effort. As our project moves along, this area must be systematically approached.

PROGRAMMED AUDIO-VISUAL TRAINING FOR THE MENTALLY RETARDED

Edmund C. Neuhaus

Edmund Neuhaus describes a successful project of programmed audio-visual training for mentally retarded young adults in the highly competitive electronics industry. This project is unique in that it teaches motor skills and seeks to make them productive self-respecting contributors to the community.

A unique research and demonstration project, supported in part by the Vocational Rehabilitation Administration, employing mentally retarded adults is being carried out at Abilities Inc. The major goal of the project is to determine the feasibility of employing mentally retarded adults in a normal competitive industrial setting. One of the primary concerns of the project's methodology is exploring the effectiveness and possibilities of teaching the retarded worker vocational skills by programmed audio-visual training methods. This paper will describe the preliminary experiences and developments regarding the use of programmed audio-visual methods in training the retarded worker.

The setting of this research study is Abilities Inc. of Long Island, New York. Under the dynamic leadership of its president and founder, Henry Viscardi Jr., Abilities Inc. employs 480 severely disabled persons on electronic assembly contracts. Competing successfully with local industry, this electronics plant is now training and employing mentally retarded young adults on industrial and commercial job operations. From the Human Resources Fundation, the research and teaching division of Abilities Inc., the necessary professional and supervisory staff is obtained.

The population comprising the research group includes 25 mentally retarded individuals between the ages of 18 and 30, with mental levels that fall between the I.Q. ranges of 60 and 80 as obtained by the Wechsler Adult Intelligence Scale. Their academic skills are at the 3rd to 5th grade level of achievement in basic subjects. They display neither emotional or organic problems that would interfere with a work adjustment. The entire group is well motivated to work and be productive in a normal competitive setting. In general, the intellectual functioning of these retardates is in the educable or high level range of mental retardation.

The retarded worker is placed in a department of Abilities Inc. that will best suit his skills. Each worker is trained on at least four or five different job operations. The retardate works alongside the normal worker. In no way is he isolated and protected from the competitive demands of industry. A training supervisor, who is a professional in the field of retardation and knowledgeable in industrial skills, maintains a close relationship with the foreman and other industrial supervisory personnel so that the retarded worker's intellectual functioning and background is fully understood by them. The training supervisor initiates the conventional industrial training period with the retarded worker, and continues the training relationship until the retarded employee demonstrates an acceptable degree of efficiency. At that time, the retardate becomes a part of the regular productive work force. Close contact is constantly maintained between the training supervisor and industrial personnel.

The retarded employees are presently working on job operations that include soldering, electrical and mechanical assemblies, wire stripping, tinning, flagging, ferulling, and laying and lacing of harness and cable assemblies. On one job contract, the retarded are performing skills that include stacking of laminations, packing and lacing of rotors and stators, assembling brush riggings, impregnating the rotors and stators, and then completing the assembly of this specific generator. The retardates are working on similar electronic assembly skills on job contracts from companies including IBM, Republic Aviation, McDonnell Aircraft, Bosch Arma, Ford Instrument, Western Electric and Remington Rand.

The project is now exploring the use of programmed audio-visual training methods in teaching the retarded those job skills found in an electronic assembly plant. The rationale for using these techniques lies in the fact that local electronic assembly plants on Long Island, such as Sperry, Republic Aircraft and others, reported a significant decrease in training time and an increase in production quality for normal workers when employing these techniques. Also, the general success that audio-visual training has enjoyed in academic circles encouraged its experimentation with the retarded. Programmed audio-visual approaches have been used minimally in teaching academic subjects to the retarded. In a recent survey of the available literature, Stolurow (1963) found only 14 research projects using programmed instruction for the mentally retarded. These projects dealt primarily with reading, spelling, language, arts, arithmetic and reasoning. Their use in teaching vocational or motor skills to the retarded adult is clearly a pioneer and uncharted area. Even in the teaching of motor skills, per se, to normal adults, audio-visual methods have been used only to a very limited degree.

The programmed audio-visual phase of this research study has proceeded cautiously and slowly. The equipment chosen was the Videosonic audio-visual aids produced by Hughes Aircraft. This is an easily operated machine that accommodates slides placed in an automatic feeding cartridge and gives simultaneous audio-type instructions. The slide presentation can be paced by the individual's own needs. An audio-visual training area was set up with four Videosonic machines and individual work stations that are completely equipped with appropriate work materials.

The first exposure given the retarded population with audio-visual equipment consisted of an orientation or trial run assembly of a "rabbit ear" television antennae. This trial run afforded both the retarded group and the investigators an opportunity to become familiar with the "hardware" under actual operating conditions. Moreover, it allowed the investigators to obtain an initial reaction from the retardates concerning this new and novel training approach.

The television antennae assembly program included 35 colored slides with audio-tape instruction. This program was developed by Hughes Aircraft Company specifically for experimental purposes for retarded adults attending a sheltered workshop in California. At the time of this trial run, our research population numbered 15 retardates. Each was asked his reactions to this type of training upon completing the antennae assembly. The comments were unanimous in preferring the audio-visual method over conventional training approaches. The retarded remarked on the clarity and consistency of instructions and the excellent opportunity it gave them to see exactly what was required in each job step. Many pointed out that different supervisors and foremen usually gave conflicting, inconsistent, and unclear instructions, while this was not so with the audio-visual presentation. In general, they reacted most favorably to the programmed audio-visual training approach, and were especially attracted by its meaningful presentation.

Developing an actual audio-visual program for one of the important skills required in Abilities Inc. was now our next step. It was decided to program the skill of plug soldering (or, more specifically, the skill of soldering wires to a cannon type connector). The soldering skill was chosen since it is one of the most important and eagerly sought after skills in an electronics assembly plant.

A small consultant staff of programmers and technical assistants experienced in developing audio-visual aids and programs for industry met with the project's staff to plan the plug soldering program for retarded workers. It was extremely important that these consultants be made aware of the retarded workers' level of intellectual understanding. Moreover, our staff's intimate knowledge of the skill to be programmed and the retardates' functioning in an industrial setting was invaluable knowledge in contributing to a successful program. Time and time again, the technical consultants required our professional staff's recommendations before an individual slide was photographed for final inclusion in the program. Similarly, in the writing of the audio script, the professional staff trained in mental retardation, had to edit and constantly revise the narration so that it was meaningful to the retarded employee.

Some of the principles that guided us in developing the audio-visual instructional program in plug soldering for the retarded worker included the following.

First, the skill to be programmed had to be broken down into as many independent job steps as possible. A very thorough process of job simplification was carried out. This served as the foundation from which to build the program.

Secondly, repetition of job steps was most important. For example, instructing the worker as to the proper manner in which to hold the soldering iron was repeated in the program every time a new pincup was to be soldered. Although a specific job step was presumably learned and being performed efficiently by the retardate, its instruction was nevertheless repeated in subsequent job steps whenever appropriate. It has been our experience in teaching industrial skills to the retarded that such repetition combats forgetting or improper execution of the skill. The practical application of this principle directly influences the length of the program. The total number of slides comprising this plug soldering program is 216 which is divided into 6 separate sub-programs or sections of 36 slides each. Each of these sections or sub-programs is devoted to one major aspect of the plug soldering job operation.

Thirdly, verbal instructions need to be brief and easily understood. A knowledge of the retardate's academic level of achievement and his language usage was necessary when writing the script. Here, too, repetition was used. The same type of words and phrases were used over and over again. Sentences were as short as feasible. Technical words that are part of the operation programmed were never changed in any way. They were repeated and emphasized accordingly; in this program such words were *inhibisol, flux,* and *solder*. It should be noted that the narration was done by the training supervisor, the voice of a person with whom the retardates were already familiar.

Lastly, the staff struggled with the problem of reinforcement or feedback. There was no practical or economically feasible manner in which the equipment could inform the retarded worker whether or not his response was a correct one. The feedback set-up would have had to be extremely sensitive and complex to accomplish this purpose. Moreover, the job skill of soldering does not require absolute type of responses, but allows a fine range of response variations that are still "correct" responses. This is the case for many industrial skills. The problem of feedback was resolved by having a training supervisor present while the retardates were following the audio-visual program. Since there will be no more than four retardates learning this skill at one time by the audio-visual program, a supervisor checking the work seemed the most feasible way to work out the question of reinforcement. When one considers that it takes approximately six months of conventional individual training and supervision to train a normal worker to become an efficient solderer, this use of one supervisor with the audio-visual program becomes acceptable from an economical and practical viewpoint.

At this writing, the audio-visual program outlined has just been completed. Only preliminary trials have been run with some of the retarded workers. The project has not collected any substantial or definitive data regarding the efficacy of audio-visual programs for the retardate. This paper is in the way of a preliminary report. However, there are impressions and observations that the author wishes to make at this time.

One of the important values that this training technique holds for the retarded lies in its ability to capture and hold the attention of the retardate. The problem of distractibility is evident in many mentally retarded. When those retarded workers who displayed difficulties in attention were exposed to the audio-visual program, this difficulty was greatly alleviated. They were more attentive and less inclined to look around and become distracted when responding to the audio-visual training technique.

Another interesting finding has been that in programming a skill for the retarded, the staff learned much about their own training techniques and the jobs being taught. This intensive involvement of analyzing and evaluating one's own personal resources while programming forces one to learn and, in some cases, modify professional approaches and concepts. Programming a skill certainly helps the teacher learn from his techniques.

It is felt that programmed audio-visual training may have significance as aids in orientation and production, in addition to its training function. Once this project's training data has been evaluated, the author plans to develop audio-visual programs relating to teaching the retarded basic knowledge about tools, equipment and typical work or factory procedures and regulations. Its value and potential as a production pacemaker will also be explored. Once a worker has learned a job skill and is on the production line, the feasibility of pacing his production by audio-visual methods is an interesting possibility.

It should again be stressed that this paper is merely a preliminary report on the thinking and developments, to date, of a pioneer project that is using programmed audio-visual methods of training the mentally retarded industrial job skills. The staff of the project does not envision audio-visual training techniques as a replacement of the individual supervisor, but as a training aid that has a tremendous potential for the retarded. That this potential can be more clearly defined is one of the project's major goals.

LINGUISTICS, LANGUAGE, AND DYSLEXIA*

Rudolph C. Troike

After a long and systematic discussion of the nature of language writing, language development, and reading and reading disability (dyslexia), Rudolph Troike points out that programmed instructional techniques may yield results through syntactic structural drill in the treatment of reading deficiencies that have remained uncorrected by other remedial techniques. Programmed instruction seems ideally suited to the carefully controlled, but motivating presentations and repetitions of materials that are needed to condition the child to the phonemic-graphemic correspondences of English. The reader can draw his own conclusions for its usefulness in other languages.

It seems as appropriate as it is unusual to have a linquist participate in a symposium on the subject of reading disability (dyslexia). Man is the symbol-using animal *par excellence* and language is the symbolic system which forms the basis for much of human culture and social interaction. As the science which concerns itself most directly with the nature of this symbolic system, linguistics has a unique and vital contribution to make toward a better understanding of language disorder and symbolic dysfunction in general.

Linguists, as linguistic scientists are known, have concentrated their work on the analysis of language structure, in an effort to discover the formal mechanisms used by speakers of a language for communication. Questions of speech development and language dysfunction have thus far been of only peripheral concern to linguists. But linguistics holds the promise of a major contribution to the elucidation of these matters because of its emphasis on the fundamental structure and operation of language. An understanding of the nature of linguistic phenomena is of basic importance to the dvelopment and implementation of corrective treatment for language disability.

We may begin by considering some of the terms in a general definition of language. In the broadest sense, language is *any system of arbitrary, conventional symbols used for communication.* The demands of communication require that the use of symbols be organized into a patterned system; their occurrence cannot be entirely random and unpredictable. Thus, a sequence of dance gestures, or the dance of the honeybee, or the utterance "The dog bit the man," each manifest an underlying system of recurrent patterns of relationship among their constituent elements. The basic units of language are arbitrary, conventional symbols: *symbols* because the units "stand for" their referents; *arbitrary* because there is no inherent connection between the symbol and its referent- and *conventional* because it is essential that the referent be known and agreed upon by those who use the symbol. Thus, the word *horse* meets the conditions of this definition. The sounds used in this word bear no real connection to the animal, *Equus Caballus;* but as used by English speakers, there is common agreement as to what they refer to. To speakers of other languages, this sequence of sounds carry no such information. Similarly, for a speaker of English to use *horse* to refer to a dog (*Canis familiaris*) would be to invite confusion; consider, for example, the reaction to such a statement as "I keep my horse in the house." In order for the meaning of a message to be successfully transmitted, therefore, both the sender and receiver must be parties to the same set of agreements as to the value of the symbols and the system in which they are used.

The acoustic signals used in speech are organized into a system of contrastive sound-units for which the term *phoneme* is used. We know that the speakers of a language do not react to "pure sound" as such, but are conscious only of those distinctions in sound which function to differentiate words in the language. A native speaker has trouble hearing or recognizing sub-phonemic (non-contrastive) sound variations such as that found in the two "p-sounds" (bilabial stops) in *pin* and *spin*. This correlates with the observation that the child's acquisition of the neuro-muscular control required to produce this sub-phonemic difference in sound seems to be an unconscious development.

The concept of the phoneme enables one to predict learning problems from the speakers of a given language who undertake to learn any specific second language For example, a person with a Spanish-speaking background who fails to make or hear a distinction between English *ship/sheep,* etc., does not have a speech or hearing defect, but is simply reacting in terms of his native Spanish sound-system, which has only a single phoneme /i/ where English has two, /I/ and /i/. As will be seen in a later section, an understanding of the phoneme also serves to clarify certain prevailing misconceptions about language development in children.

The *grammatical system* specifies the relationships obtaining among the vocaubulary elements. Part of the

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* Editor's note: Even though this paper has little direct concern with programmed instruction it was felt by the editors that the material presented had strong implications for the instructional technology.

"meaning" of any utterance is given by its grammatical structure. This may be shown by several examples:

(1) John hit Bill *vs.* Bill hit John.

Despite the fact that the same words are used in both sentences, they do not have the same total meaning. The difference in meaning is due to the underlying sentence pattern *actor-action-object* which determines the significant relation of the words to one another. In English, the syntactic device of relative *word order* is important, because it signals vital information of the type just illustrated, as well as other types; *e.g.*:

(2) This is a house guest *vs.* This is a guest house.

(3) He is still standing *vs.* He is standing still.

Thus we see that for English at least, we cannot simply add up the separate meanings of the individual words, as if they were numbers, and expect to arrive at the total meaning of the sentence. An important part of the meaning is contributed by the implicit structure of the sentence pattern.

(4) The ______ ______-s ______-ed ______-ly
(Adj.) (Noun) (Verb) (Adv.)
in the ______-ish ______.
(Adj.) (Noun)

In addition to word order, structural relations may also be signaled by *function words* (such as *the, a, in, to, of,* etc.) or *word affixes* (inflectional suffixes: *-s, -ed*; derivational suffixes: *-ly, -ish*). Each of these three grammatical devices may be more or less important, or even absent, in other languages. In the example above, only the sentence skeleton is shown. The blank spaces may be filled in with various words to produce many different sentences, but only a certain class of words (shown by the part-of-speech identifications) may be used in each particular blank. The information signaled purely by the grammatical framework of the sentence may be termed "structural meaning."

The types of words which would fit into these blanks to form meaningful sentences may be called *content words* to distinguish them from function words. Content words make up the vocabulary and provide the principal content, or "lexical meaning," of utterances. As the vocabulary of a language reflects the content of the culture, it is an important element in the enculturation of the child. Nevertheless, it is too easy to overrate the importance of vocabulary and ignore the much greater significance of grammar. The grammatical system is the real heart of the language, and its mastery is a prerequisite to successful cultural learning and social training.

It is important to realize that language is a social phenomenon, part of man's cultural behavior. The langauge which any individual uses is the result of his conditioning to the system used by others around him. Like other aspects of culture, language changes constantly with respect to time and space. A group of people who use a single undifferentiated system may be termed a speech community; two speech communities exhibiting observable linguistic differences in vocabulary, grammer, or pronunciation, but whose speech is mutually intelligible, may be said to have different *dialects.*

Dialects arise as a natural product of frequency of communication within and between geographical areas and social strata. In any language used by more than a single in-group, there will be dialects. In the United States at the present time there are several regional standard dialects which are the product of our history of settlement and westward expansion. While recognition of these facts forces abandonment of the myth of "'pure" or "correct" English (or Spanish or German, etc.), an awareness of the sociological status of different dialects and styles provides an objective basis for determining the goals of language instruction. The regional or local prestige dialect, rather than some abstract set of absolute rules, should form the model toward which a teacher should intelligently guide her pupils' speech-ways.

Widespread misunderstanding of the relation or writing to speech and language has proven a severe obstacle to the development of adequate reading materials and programs in American schools. This misconception arises from the naive and false assumptions that writing, because of its permanence, is more basic than speech, and that written English, is *the* language, from which the imperfect usages of speech derive. This fallacy often finds its expression in such phrases as ". . . the sound of the letter *h.*"

It must be stressed that language is basically *spoken* and *not written.* Writing is a secondary or derived system of symbolization which attempts to represent the phonemes of a language in a visual, preservable form. Despite the enormous importance of writing in our civilization, the course of language development would scarcely be affected if all writing were to disappear from the earth.

A realization of the true nature of writing is essential to a proper understanding of the reading process and the preparation of special reading materials. The child, who is already equipped with a speaking knowledge of the language, is taught to associate his speaking habits with a set of visual symbols. Under ordinary circumstances, he learns to decode the visual stimulus into its spoken referent (language), then decode the language stimulus for its information content. Reading is thus a two-step process, and reading skill is, to a large extent, dependent upon the mechanical facility and speed with which the child is able to perform it.

The notions that the printed symbols literally contain sounds (which the child "gets out" of them), or that the reader goes directly from the visual stimulus to the idea which it represents, both represent misleading fallacies which continue to impede the adequate teaching of reading. For children with any degree of involvement with dyslexia, these fallacies and their attendant teaching philosophies may impose additional or insurmountable handicaps to the mastery of reading.

Studies carried out by Irwin and others at the State University of Iowa have established two periods of *prelinguistic* behavior in children. The first, which extends from birth to about the third month, is marked by the reflexive sounds associated with physiological states. Considerable attention has been given to the types of sounds produced by the infant during this time.

From the third month through the eighth month, apparently as a result of maturational development, the child goes through a period of babbling, in which the sounds are produced primarily as a result of autostimulation. A profusion of sound-types are produced, including many which will not be needed for the later language.

Toward the end of the first year the child begins a transition from an egocentric to a social orientation. This period, which may be termed the *proto-linguistic stage,* finds the child beginnig to react to words and sounds produced by those around him, by imitating them. From his first birthday to about eighteen months, he learns individual words as true symbols, and builds up an active vocabulary of about twenty items. He also develops a new type of vocal behavior termed variously "jargon" or "jabbering."

Following the eighteenth month, and concomitantly with maturation of Broca's area in the cerebral cortex, the child enters upon the formative phase of the true *linguistic stage* in learning. Some recent research on this phase (Braine 1963, Glanzer 1962) has shown how the child develops a rudemintary grammar involving two-word sequences, and gradually expands and differentiates this until his utterances develop a grammatical structure closely matching that of speakers around him. Seemingly the child possesses an innate capacity for forming inductive theories about grammatical structure (Teeter 1963, Chomsky 1962), and the capacity perseveres until about the onset of puberty. Up until this time, the learning of a second language can be accomplished with much greater ease and rapidity than at any time thereafter.

From the time a minimal grammatical structure is achieved, through the sixth or seventh year, the child passes through what might be called the developmental phase of the linguistic period. This is a time of continual practice on the basic grammatical patterns and the acquisition of additional vocabulary. Smith (1935) estimates that children of 3 to 4 years in age speak over five million words a year. With the achievement of an adequate degree of linguistic competence and sensory-motor maturation, the child is prepared to begin formal schooling, wherein he will be instructed through the medium of language and will learn the difficult and complex skill of reading.

Although the question of "reading readiness" is still insufficiently explored and fraught with folklore, linguistics can provide some important insights into the matter. Beginning with the proto-linguistic stage of language development and continuing through the developmental phase of the linguistic stage, the child gradually learns to recognize and produce the phonemes of his native language. This is a gradual process, and may extend into the sixth or seventh year. However, children with severe hearing loss, aphasia, or mental retardation may never learn all the phonemic distinctions of their parental language.

In general, it may be said that a child has not mastered the phonemes of his language until he is able to consistently control their use in the pronunciation of otherwise identical words (*e.g., th*in/*s*in), and react to them appropriately. The random production of a given sound during the earlier stage of babbling has no relation to its use by the child as a phoneme in the later language.

Since reading involves the association of visual stimuli with the phonemes and phoneme-sequences of the native language, reading-readiness involves as a prerequisite the child's mastery of the phonemic system of his language. If the child has not learned to differentiate the pronunciation of /w/ and /r/, for example, he will not be able to determine which symbol represents which sound. Since English orthography is largely phonemic (*i.e.,* there are regular correspondences between the printed symbols—graphemes—and the phonemes), the failure of the child to hear certain sound distinctions will increase the burden of learning to read, and will inevitably contribute to his confusion and frustration.

Dialect differences sometimes cause problems and lead to misunderstanding, especially if the teacher and pupil are from different dialect areas. The failure of speakers in large areas of the United States to differentiate the vowels in *pin/pen, tot/taught,* and *hoarse/horse,* or the initial consonants in *which/witch,* should be recognized, and children should not be criticized or penalized for this by forcing them to produce distinctions which are foreign to their native dialect.

The large residue of English spelling which is not phonemic has to be approached by different teaching techniques. There are very few words whose spelling bears *no* relation to their pronunciation, but there are many which bear only partial relation. In addition, there are problems of multiple representation of the same sound, as well as identical representation of different sounds. When the *phoneme:letter* correspondence does not hold, the child must be taught to memorize individual *word:letter-sequence* correspondences. The amount of such information which an individual is capable of storing seems to vary widely, but well-organized materials and teaching techniques should serve to bring the child closer to his maximum capacity.

Reading disability (dyslexia) represents a specific manifestation of a more general disorder, that of symbolic dysfunction. Dyslexia refers to the inability to associate visual stimuli and linguistic responses. This inability may be inherited or acquired; it may be due to physiological, functional, or psychological causes; and it may occur independently (primary dyslexia) or in conjunction with other types of symbolic dysfunction, such as aphasia (secondary dyslexia). It is also important to note that individual involvement may range from marginal to complete.

The tremendous premium placed upon literacy in our modern society emphasizes the significance of reading ability as a culturally important skill. Children with primary dyslexia may be helped by a linquistically sophisticated teaching program and appropriate teaching materials. In severe cases, where no complications are involved, the child may be helped by supplementary oral instruction and drill in much the same way that blind students are enabled to go through school and college programs with the tid of "reading assistants." Emphasis on the development of oral recall ability would perhaps enable such individuals to partially overcome their handicap. Certainly, many teaching procedures associated with both the "phonics" and the "look-say" approaches to reading instruction are deleterious to children with even minimal dyslexic involvement.

One of the difficulties in the treatment of dyslexia is the failure of teachers to diagnose the problem soon enough. Where dyslexia occurs together with or as a reflex of other language-development problems, the child may be designated for special treatment from an early age. When it occurs alone, however, it will not become apparent until reading instruction begins, and may be difficult to differentiate from cases of slow learning. Delay in diagnosis prolongs the frustration and embarrassment of the child in his reading experiences, and renders his problem increasingly intractible of treatment.

Although the general outlines of language ontogeny in the child are known, detailed descriptions which would permit the early diagnosis of aberrant development are not yet available. Research currently in progress, based on the linguistic model for the description of syntactic structure developed by Noam Chomsky (1957), promises to yield important data in the near future. Previous investigations in this area have not had enough linguistic sophistication to provide precise, meaningful results.

While indices of gross vocabulary size provide some indication of the language development of the child, more significant indices based on the rate of syntactic development can be devised when these studies have been completed. The child's mastery of the structural devices of his language should provide the most reliable indicator of his linguistic development.

As mentioned previously, most children appear to have a native capacity for inductive theory formation with respect to language. Where this faculty fails to function normally, it may be that carefully designed structural drills—such as those used for teaching English as a second language—may be employed for remedial instruction. These could be started fairly early, and their use might help to compensate for the child's deficiency by forcing pre-analyzed patterns on his attention. This is clearly an area in which programmed instructional techniques, coupled with linguistically adequate materials, could be usefully applied.

In cases of simple primary dyslexia, programmed instruction seems ideally suited to the carefully controlled, but motivating, presentation and repetition of materials that is needed to condition the child to the *phonemic:graphemic* correspondences of English. Ordinary classroom teaching does not provide the intensive conditioning and linguistically-devised materials which may be necessary to overcome the handicap of dyslexia.

The problems of language disability have been extensively studied by neurologists, psychologists, and speech pathologists, and from their work an important body of information relating to the subject has been amassed. Much previous work, however, has been weakened, or even vitiated, by insufficient knowledge on the part of the investigator regarding the structure of English, the nature of language, or the relation of writing to speech. Specialists in the study and treatment of language disorders have pointed out the need for closer collaboration with linguists to provide a better understanding of the substantive features of linuistic systems. It may be hoped that the awareness of this need will become mutual, and that linguists will contribute their knowledge and experience to help provide a truly multilateral attack on this grave and difficult social problem.

VI Industrial Applications

AEROSPACE INDUSTRIAL PROGRAMMING (PAST, PRESENT AND FUTURE)

Jac D. Meacham

Jac Meacham briefly reviews a few of the aerospace training situations in which programmed instruction has been and is currently being used. The use of programming will undoubtedly continue in the future. Jac Meacham feels that the automated instruction will also prove useful in the area of aerospace system analysis and design.

Aerospace pertains to the earth's envelope of atmosphere and the space above it, two separate entities considered as a single realm for activity in launching, guidance, and control of vehicles which will travel in both realms. Aerospace industries are those companies that are actively engaged in furnishing products and services for aerospace forces. With the increased complexity of aerospace equipment, the problem of communication and training becomes extremely important and a constant vigil must be maintained to provide the using personnel with adequate and up-to-date information. The technical information required for aerospace products and services is no small item and it far exceeds that of all the combined publishers of commercial material in the country, the technical information required by the users of aerospace equipment must be: *Understandable, accurate, complete,* and *usable* under the most difficult situations.

Decentralization of the producer of aerospace data and the user has compounded the situation to the point where something nearly revolutionary must take place in order to reduce the danger of our becoming technologically inadequate and insufficiently qualified to perform the demanding tasks of space-age existence. What does all this have to do with programmed instruction?

I feel that a solution or partial solution to the vast problems of aerospace communication and training lies in programmed instructional materials. The need is great for uniform standardized aerospace technical data and control of the material presented. This can, and is, being accomplished via teaching machines and programmed instruction concepts. Aerospace industries are, or should be, faced with the task of preparing this material and they must be prepared to increase their ability to produce good quality programs. The ultimate objective as I see it, is to produce programmed instruction that would result in uniform interpretation and understanding, and maximum utilization for the Shorty Powers' and John Glenn's of tomorrow . . .

Both the aerospace industry and programmed instruction, despite their revolutionary characteristics, are additions to our recent past. The aerospace industry's past is well known to most, but the programming aspects of this dynamic field may not be. The beginning of programmed instruction as a part of the aerospace training curriculum actually began to take shape in an underwater project, the atomic submarine.

A handful of men went to work on a unit called a "teaching machine." The ultimate device actually turned out to be more of a "guidance machine" in that most presentations *guided* the worker in accomplishing a procedure, rather than *teaching* him the procedural steps. The efforts of others began to show up in the research and development phases. These pioneers showed early success in the fields of shipboard missiles, supersonic airplanes, and other military training areas.

Not too long ago, the aerospace industry was faced with a requirement which assured a schedule and plan of completion for events and activities to be used on aerospace projects. The result was a concept called PERT (program evaluation review technique). Thousands of people needed to use the system, many furnished input to the system, and still others were required to coordinate and develop the web of information. A training problem had to be solved before PERT could be implemented. Several organizations started to program the material and at least two successful programs are now available for aerospace contractors. Today, across the nation, widespread and comprehensive PERT training can take place in less than an 8-hour work day.

Another page out of the past demonstrates the use of programmed instruction in the operational aspects of aerospace products. *KIFIS* (Kollsman Integrated Flight Instrument System) corrects, combines, modifies, and refines information from aerospace instruments and provides the pilot with additional information to make his job easier. Extensive experience in a classroom situation indicated that the subject was difficult to teach due to variable understanding among the students. It was decided that programmed instruction might take care of some problems of boredom, absorption, and pacing that existed. The results were not astonishing but did show that this type of training was accomplished faster and with greater student acceptance and understanding.

Other efforts in the past, that have produced some of the well known benefits of programmed instruction, include:

1. *Safety Precautions for Nuclear Weapons*—a program designed for crew members who are responsible for loading weapons on the supersonic high performance aircraft that protect our nation. This program teaches the aspects of personnel safety as pertains to the weapon and the weapon system.

2. *The Rocket Package Test Adapter*—a program designed to meet the needs of loading crew members, and contains information on how to operate and maintain the Test Adapter.

3. *Flying Safety Views*—a program that discusses the controversial problem of ejection vs. forced landing and provides the pilot with the knowledge that will enable him to make a decision based on fact. In passing, we also note *The Arrest Hook System* for the F-102 aircraft, the *Value Control* program, the *Ejection Seat*, the *F–106 Hydraulic System, soldering, test and launch stand operation and maintenance, task analysis* and many many other efforts that are part of the past aerospace programming work. The success of these early programs have demonstrated the desirability and effectiveness of programmed instruction as a potential solution to the vast training and instructional problems of aerospace technology and related fields.

The armed forces are showing much interest in the field of teaching machines and programmed instruction. The Air Force, with its two-phase attack, is currently going from development of programmers and programs into direct application. *Sage, Electronics, computers,* and other military oriented programs are being utilized daily by Air Force personnel at home and abroad. The Navy is utilizing programmed instruction for seamen in the maintenance and operation of shipboard missiles. Great Lakes Naval Training Center and other training and testing sites are installing programmed materials for their students.

Several large aerospace contractors have actively engaged in the use and development of programmed materials. These aerospace oriented firms are programming for in-house use and for military users. Weapons and weapon systems are being studied. These include among many others missile components, operation, guidance, launching, recovery, safety, overhaul, storage, and retrieval problems. The commercially available, academic, oriented programs are also being utilized by aerospace industrial and military personnel to provide a foundation or springboard for more complex systems and procedural programs. Off-the-shelf programs for aerospace users are very limited and many courses are needed.

Present use of programmed materials in the aerospace industries show that programmed instruction can:

Accelerate training.

Permit training and retraining on a non-scheduled or remote-site basis.

Release instructors for advanced and supplemental duties.

Relieve the critical shortage of qualified instructors.

Standardize complex technical instructional material.

Future use of programmed instruction within aerospace industries is being assured through research and development of specifications for programmed instruction in FASTI, Astro-Aid, CLASS, and many more subjects. Programmed instruction for aerospace industrial use will continue to grow with the complexity of the equipments and lack of qualified and well trained personnel necessary to operate and maintain them. The procedures for operating and maintaining equipment *MUST* be efficient, reliable and safe. Scientific knowledge concerning human performance will be applied for the purposes of:

a. Achieving system performance by appropriate use of the man as a system component.

b. Developing, selecting and designing equipment, procedures, and facilities to insure efficient, reliable and safe human performance within the specified tolerances.

c. Reducing demands on manpower resources, skills, training, and procedural data within the established parameters.

These and other factors directly offer the programmed instruction field as a solution to the problems that are facing aerospace industries today for tomorrow's space flights.

INDUSTRIAL PROGRAMMED INSTRUCTION IN VALUE CONTROL TRAINING

Charles M. Keys

Charles M. Keys reports on a programmed instruction package which was developed for use in Value Control or Value Analysis training of industrial employees. This program effected a significant reduction in the training time over the conventional course without a loss in training quality. In addition to a savings of nearly forty percent in training time, value control could be applied to a Value Analysis Course.

Industry today is faced with intensive competition both from within the United States and from other countries which are challenging the superiority of the American industrial genius. Competition is keen from within our country because of the tremendous technological advances in recent years and the cold, hard fact is that West Germany, Japan, France, Italy, and Sweden, to name a few, are succeeding in competing with us for the world trade dollar.

In an effort to meet this challenge, industry is pressed with the need to make all employees more cost conscious than ever before. This applies especially to employees who are placed daily in positions which require them to make *cost* decisions. One management tool which has been developed in recent years to give industrial employees a specification for making cost decisions is "Value Control".

Value Control is also known within industry as "value engineering" and "value analysis." Its design is to shape the performance of industrial employees in such a manner that they will make cost decisions which will result in the best value for the dollar. Very briefly, Value Control is the systematic application of certain techniques which:

1. Identify the function of a product of service
2. Establish a value for that function.
3. Endeavor to provide that function at the lowest total cost without degradation.

Unnecessary costs are eliminated and suitable alternatives are developed. While the phases of the Value Control process are neither new nor revolutionary, they are tied together in a neat package and presented in a seminar/workshop training program to create a cost-conscious atmosphere.

The importance of a value control training program is pointed out by the Federal Government's attitude toward the subject. In recent years, value engineering "incentive clauses" have appeared in many Government contracts. Recently, value control has become a mandatory requirement in some types of Government contracts and is provided for in the Armed Services Procurement Regulation.

The decision to convert the Value Control Training program to a programmed instruction course was a simple matter of applying value control to Value Control. The training course was studied to determine how it could be streamlined to reduce costs and increase effectiveness. Programmed instruction was the answer. It was apparent that an internal training situation could be improved simultaneously with the development of a marketable product. Hence, under "contract" from the Training Department and with the full support of the Manager of Value Control, the Convair programmed instruction group attacked the project.

The subject of Value Control lends itself to division into five fairly distinct parts. This division conformed very well to the requirement for conducting a workshop concurrently with the presentation of the subject matter in the actual training situation. The five segments which were programmed were:

Orientation (an overview of the subject)
Identification (of the function) and Information (gathering)
Speculation (developing alternatives)
Analysis and Selection (of the best alternative)
Presentation (selling the alternative)

Since the "customer" was serving as subject matter expert, the development of content outlines and course objectives was somewhat simplified. The guidance provided by our Value Control Coordinators was reasonably specific and the limits of coverage were well defined.

The programming task, however, developed into much more than a simple conversion of an existing course to programmed format. The lecture course, as it had been taught, had no content examination and little printed study material. There was no text. The lectures were given by qualified personnel from many different areas of the company. While this method was effective, it was also somewhat cumbersome and required extensive coordination with many people prior to and during each seminar. This same extensive coordination was required by the programmers in accumulating subject matter and source data.

As previously stated, the curriculum content was divided into five parts. Accordingly, a five-man team was used, with each programmer assigned the responsibility for development of one of the parts. When a team is used, it necessitates close coordination between the programmers, particularly during the initial development of content outlines and specification of objectives. Careful and frequent editing of programmed material is required to prevent duplication and overlapping coverage.

A team project also has some advantages. Primary among these is the fact that all members gain extensive knowledge of the entire subject matter. Each programmer can then edit the material of the other team members and provide suggestions for improvement of subject matter content as well as programming methodology and technique. This is quite fruitful, especially when the group is compatible and the project is a bonafide team effort.

Because of the nature of the subject matter, a branching technique was used. Some "linear review" of key material was used, but, for the most part, the requirement was that the student discern a correct response from a group of two, three or four possible alternatives. In addition to the extensive editing by the team members and project leaders, first and second drafts were tested on approximately twenty typical subjects to determine deficient and weak areas.

The next phase of development consisted of testing the drafts in a formal seminar consisting of twenty students. The texts were used in conjunction with a workshop project with some experimentation to determine how best to fit them into the workshop phases of the actual training situation.

After a careful review of the students' accomplishments and with additional feedback from the Value Control coordinators, minor revisions were made to 40% of the 350 frames and the first edition was published. This edition was used in formal seminars on forty students and minor revisions were made prior to publication of a revised edition which is currently on the market.

The results of the final testing of the programmed texts were most gratifying. The total course cost and classroom time were reduced by more than twenty-five per cent. A valuable asset was gained in the improvement of the flexibility of class organization and presentation of material.

As previously discussed, the lecture course had used guest speakers who held key positions througout the plant. There was approximately twenty-four such lectures which not only required the speakers' time but necessitated large classes (thirty to forty students) in order to justify the time spent by the speakers.

With the development of the programmed texts, the classes may be much smaller (fifteen or twenty students) offering a better opportunity to perform on workshop projects. These projects require that the classes contact many departments in the plant and with the smaller classes, the persons contacted can give each team of students more time and consequently better information.

The following table shows a comparison of the conventional training methods versus the programmed texts.

	Conventional Training Methods (Lectures) (N = 50)	*Programmed Instruction (N = 50)*
LECTURE TIME	10 Hours	30 Minutes
READING TIME	30 Minutes	6 Hours
TOTAL CLASSROOM TIME	10.5 Hours	6.5 Hours
EXAMINATION RESULTS	No formal exam given	90% Correct
WORKSHOP RESULTS	Students in both workshops demonstrated equal ability in accomplishing the phases of value control	

In addition to full-scale use in the Convair Value Control training program, the programmed texts are being used by other General Dynamics divisions. They are also being used by San Diego City administrators and by the U.S. Navy in San Diego. There have been numerous inquiries from other potential customers.

When a project is completed and the "gains" and "losses" are tabulated, it is most gratifying to see in retrospect that more has been accomplished than was initially anticipated. Such was the case with Value Control. Many "side-effect" benefits may be realized by the conversion of an existing industrial training course to programmed instruction. Looking at the additional benefits at this time, it is easy to say that they should have been anticipated. The bonus received was in the form of the following:

1. Conversion of an existing industrial training course to programmed format forces you to take a close look at your training material. It offers an excellent opportunity to revise and update the subject matter and reorganize it around a tight outline to improve consistency of training.

2. The conversion causes you to more clearly specify your training objectives and determine if training time is really being used to the best advantage. When you start the change to programmed instruction you should ask, "Are the students in the existing course learning what they must know in order to perform the duties for which they are being trained?". Do not assume that the existing course is doing this.

3. Converting a course such as Value Control to programmed format creates a renewed interest in the subject within an organization. In this case, the entire

Value Control program was given added importance because the training program was doing something new and was being widely discussed and publicized. The training effort was in the limelight because of the "experiment" and there was increased enthusiasm at the top management level and throughout the ranks.

4. Although anticipated and not really a side-effect benefit, one additional asset gleaned from the conversion was the enhancement of the overall programmed instruction effort. The programming group gained valuable experience and the concept of programmed instruction was publicized and more widely accepted throughout the company. The boost to programmed instruction was so great that it accelerated our efforts into new areas of endeavor. We are currently programming quality assurance training courses for in-house use on such subjects as Material Review Board, Nondestructive Testing, Traceability, and other hardware inspection techniques. This new effort would probably not have been as readily accepted had it not been for the success of the initial endeavor, Value Control.

TECHNOLOGICAL CHANGE AND THE JOURNEYMAN ELECTRICIAN: AN EXPERIMENTAL STUDY IN CONTINUING EDUCATION*

David S. Bushnell

David S. Bushnell outlines the problems associated with adult education and describes a research program which utilized programmed instruction and teaching machines in this field of teaching. The study, conducted by Stanford Research Institute, taught journeyman electricians the fundamentals of electricity using programs only, a combination of programs and teachers, and teachers only. The study showed that the use of teaching machines combined with teachers reduced training time, motivated the student, and allowed for individual differences through self-pacing. Mr. Bushnell concludes his report by proposing several areas for further study.

Last year over 26 million adults, one out of every five in the United States, participated in some form of educational activity. Almost any organized group that you could name, industries, churches, professional organizations, sponsors one or more programs of adult education. Most of this adult learning was of the non-credit type and was concentrated most heavily within the areas of vocational and recreational subject matter. According to a recent report by the National Opinion Research Center (Johnstone, 1963), one-third of all adult education studies are in the vocational sphere.

With increasing amounts of leisure time and greater specialization of work skills, the emphasis on vocational education promises to increase within the next few years. Initial employment skills, once thought to be all that was needed to maintain a person throughout his entire career, must now be upgraded or revised several times to adapt employees to technological advances. The retraining of workers whose skills are in danger of becoming obsolete has become an important part of the national effort to maintain the current level of employment and rate of technological growth.

But training effectiveness, particularly in those industries which rely upon voluntary participation, has been hampered by at least three factors: (1) the unwillingness of adults to enroll in and remain enrolled in voluntary training programs, (2) inadequate adult teaching techniques, and (3) a shortage of qualified instructors. For many skilled workers the prospect of retraining is unpleasant because of past educational experiences; some are early high school dropouts; others have been out of school for 20 or more years; others because of their previous experience have found courses to be too difficult or not appropriate to their particular job needs.

There is an urgent need for new ways to motivate adult workers to enroll in appropriate voluntary programs and to continue once they are enrolled. Improving the appeal of adult vocational training may hinge in part upon the use of new teaching techniques that permit the student to proceed at his own rate of learning without fear of failure; and in part upon recognition of the fact that adults differ from high school or college students.

Recent research has demonstrated that teaching machines are as effective as live instructors in imparting knowledge. The employment of auto-instructional techniques has reduced *IN HALF* the time required for many types of training programs. The real promise of teaching machines, however, may be their ability to overcome adult reluctance to expose themselves to the conventional classroom and to possible failure in the eyes of their associates.

Some of us at Stanford Research Institute (SRI) have been experimenting with teaching machines, not in the area of adult vocational education, but in the field of postgraduate education of dentists and doctors. We found that self-instructional procedures, or auto-instruction, appealed to this caliber of student because it allowed him to move at his own rate and almost guaranteed successful learning. The programmed material required active participation in the learning process and tested the student's knowledge at each step of the way. The student knew immediately whether he had answered a question right or wrong. Practice and review were built into the course. Whether these advantages would carry over into the field of skilled craftsman training where one is faced with a group of men who are physically tired after a full day's work and many of whom have fears concerning their ability to learn became the subject of a recent research program conducted by SRI on the problem of continuing education for journeymen electricians.

We knew that teaching machines could be as effective as teachers in communicating information but we didn't know whether they would help us carry through an effective program of instruction for an experienced group of adult workers. The study set out to answer five questions:

1. Does the use of new teaching techniques have a

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* Study sponsored by The Bureau of Industrial Education, Calif. State Dept. of Education and The Electrical Construction Industry of San Mateo County.

more positive effect on learning and achievement than does the more conventional means of instruction?

2. How are journeymen's attitudes toward training affected by the use of these new teaching aids?

3. Does the effectiveness of new teaching techniques vary with student ability? If so, how?

4. What are some of the effective ways of recruiting journeyman electricians to take part in voluntary education programs?

5. What are some of the costs involved in the use of new teaching aids as compared with the cost of the more conventional type of instruction?

The study began with the interviewing of a cross-section of journeymen and electrical contractors from San Mateo for the purpose of gaining firsthand knowledge of the journeyman's on-the-job training needs. Following this, a survey questionnaire was mailed to all members of the IBEW Local 617 with the intent of gathering data on the journeyman's educational background, his attitudes toward previous training experiences, his training needs, his work aspiration and hopes for the future. Of the over 400 questionnaires sent out, 65 percent were returned.

In carrying out the experimental training program, ninety-six men were assigned to three modes of instruction, each mode being made up of two classes which met for three hours once each week for 18 weeks. SRI agreed that it would only observe and evaluate the first nine weeks of the training, but that the course would proceed for the full semester. Of the 27 hours scheduled for study during the first nine weeks, five hours were absorbed by aptitude and pretests given on the first class night and a mid-term exam given on the ninth week of the training. Approximately 6 hours were given over to laboratory assignments and the remaining 16 hours to regular instruction (see Figure 1). The three modes of instruction varied from individualized self-paced instruction on teaching machines to a combination of machine and live discussion for review purposes to conventional instruction with the use of advanced audiovisual aids in the third mode. All three groups were given the same laboratory and outside reading assignments. Thus in Mode I students worked on self-instructional devices at their own pace. In Mode II, they spent most of their time on teaching machines, but had an opportunity at the beginning of the class to discuss and review with a qualified instructor the previous week's material and outside reading assignments. In Mode III they followed the more conventional live lecture-discussion method.

The course itself was to cover the fundamentals of DC and AC circuit theory in one semester. This was done because such a review of the fundamentals of electricity would serve the immediate requirements of two types of journeymen. *FIRST,* those who were capable and qualified of becoming electronic specialists but who needed remedial training before undertaking more advanced study and *SECOND,* those who required a refresher course but who were not qualified or motivated to go further with electronics training.

At the outset of the experiment there were ninety-six journeymen electrician students, 4 instructors, 15 teaching machines, hundreds of feet of microfilm for use on the teaching machines, two classrooms and one wornout Volkswagon for constant shuttles between Menlo Park and San Mateo.

During the experiment it was found that the students in the teaching machine mode did only slightly better than those in the other two modes on the mid-term examination. However, those in Mode I who knew

Figure 1

Arrangement and Location of Classes for the Experimental Study of the Industrial Electronics Training Program

Instructional Mode	*Class Schedule*	*Number of Students*	*Location*	*Type of Instruction by Allocation of Class Time*		
				Review (½ hr)	*Teach (1½ hr)*	*Lab. (1 hr)*
I	A	15	College	P.I.*	P.I.	Live
	B	15	College	P.I.	P.I.	Live
II	D	15	College	Live	P.I.	Live
	G	15	College	Live	P.I.	Live
III	C	18	Union Hall	Live	Live	Live
	E	18	Union Hall	Live	Live	Live

* P.I. = Programmed Instruction

more about the fundamentals of electricity before enrolling in the course, as measured by a pretest of job knowledge, were able to perform significantly better on the midterm examination than did those with similar background in the conventional mode. Lower ability students also did better in the programmed instructional mode than in the conventional mode although these differences were only marginally significant.

Over-all, the journeymen were taught the fundamentals of a direct current theory in about half the time allotted to such a course. This was possible because of the way in which the programmed instructional materials were developed; a thorough task analysis and specification of job needs has pared the course down to its essentials.

About two-thirds of the students in the auto-instructional Modes I and II said it was easier to learn from the machine than from an instructor. The machine mode by itself, however, did not result in as high a level of over-all satisfaction with what was learned in the course as did the combined machine and live mode of instruction (Mode II). Only about a quarter of the Mode I group stated they were "very satisfied" with their learning experience, whereas almost half of those in Mode II responded in this manner. Other measures of satisfaction with the training program indicated the same results. All of the students in Mode II said they would sign up for the same course if it were offered again as against 79 percent of Mode I and 87 percent of Mode III. Similar numbers of journeymen said they would recommend the course to other journeymen.

Interest in following up with continued enrollment in a subsequent course was also much higher for the students in Mode II. Eighty-six percent of this group said that they would enroll in a course which continued where this one ended, as against 63 percent in the Mode I and 65 percent in Mode III.

The over-all absence rate during the first half of the semester was five percent, excluding ten men who dropped out of the course during this period. There was essentially no difference in absentee or dropout rates between the three modes of instruction during the first nine weeks of instruction.

One interesting item differentiated the enrolled journeymen most clearly from the non-enrolled group. The enrolled group expected to see many more changes in their job in the next five years. The enrolled journeymen who expected changes in the job, and who expected these changes to be beneficial to themselves, were more likely to enroll in a training program than workers who did not feel this way.

The enrolled journeyman tended to be less well satisfied with his current level of training. In general, he hoped to move up to a higher skill level than his current one and he valued the opportunity to do interesting and challenging work.

The major implications of these findings seem to be the following: FIRST, programmed instruction worked as well as, or better than, conventional instruction in this adult education program. All of the expected advantages of teaching machines proved true. Because students could proceed at their own learning rate, those with a higher initial knowledge of the subject matter moved further ahead than those in the conventional classroom. Those who were slower and showed less aptitude also did better in the auto-instructional modes. No longer did these two groups have to suffer because the instructor was required to gear his presentation to the average of the group.

While learning is still hard work, teaching machines take the psychological risk factor out of adult education. Men who have securely established themselves in their trade have more at stake when they go into a classroom—their future and status among their coworkers. They are afraid of revealing their ignorance. Teaching machines help overcome this fear. They gave the students greater confidence in their own learning ability.

Teaching machines might become as common around the Union Hall as folding chairs and ashtrays. They could be used as remedial devices with journeymen checking them out of the Union Hall, taking a prescribed review program on their own or with occasional group meetings, and once having completed the course, checking their readiness for advanced work by passing a standardized achievement test. Those who qualified for more advanced courses would be allowed to go on. Slower students or those without sufficient motivation would be screened out.

FINDING NUMBER 2. The combination of machine and live instruction yielded the highest satisfaction. Once the initial fascination with the gadgetry wore off, the human instructor resumed his importance. Teachers won't be replaced by machines, but the machines can help speed up the training job and make instruction more effective and enjoyable. The teacher as a discussion leader helped to weld the group together and made it a more rewarding experience than individual study. The machine did a better job in allowing the student to go at his own rate and to check himself at each step of the way. The instructor could draw out the students, get them to share common problems and generally develop a feeling that they were a part of a meaningful training group.

Coupling live instruction with automated instruction costs more but should be measured against the potential savings in time. This experiment cut the length of this course by about 50 percent. This meant that some of the cost saved by cutting instructional hours could be invested in the rental or purchase of teaching machines and programmed materials.

FINDING NUMBER 3. Closely related to this last point was the fact that commercially available programs for presentation on teaching machines could be adapted to the requirements of a particular student group and at a cost considerably below that incurred by in-house programming. This experiment demonstrated that for about $3.50 per instructional frame we could obtain a satisfactory set of films for presentation on the Auto-Tutor Machine as contrasted with approximately $12.00 per frame incurred by the research team in an effort to completely reprogram one lesson of the course.

FINDING NUMBER 4. Efforts to persuade journeymen to take part in voluntary education programs were substantially aided by convincing the journeymen that through training they could take advantage of the coming changes in their work. Through questionnaires and the initial interviews the journeymen were given a chance to make suggestions about WHAT should be taught and HOW it should be taught. This application of the rule of participative decision making WORKED. The care with which the course outlines were prepared gave the journeyman some assurance that he would benefit from the training. Face to face discussions in the Union Hall or on the job carried on by the local business agent and the contractor emphasized the important role they can play in getting journeymen to take part in training. A successful learning experience—one that yields satisfaction with training—means that employees are more likely to enroll in a subsequent course than if the experience had not been successful.

FINDING NUMBER 5. It was found that adult education required instructors who were familiar with and capable of teaching adults. Adults are different than younger students and they must be treated differently. They have more at stake when they go into a classroom. If they fail it reflects on their work and possible job security. The adult applies a stricter test of the relevancy of the course material to his work than does the younger student. Like the younger student, he is concerned with being accepted by his peers. He doesn't want to evidence any lack of ability. He likes being part of a successful training group. These feelings and expectations can be enhanced by the proper combination of new teaching techniques and skilled instructors.

This study does not answer all the questions associated with adult education. In fact, it shows that the following problems must be answered. How to persuade people that keeping up with technological changes is possible and rewarding. What is the optimum combination of live and programmed instruction? What is the role of other audio-visual aids such as educational TV, simulators, and step-by-step demonstrators?

The study has demonstrated, however, that teaching machines can help answer Secretary of Labor Wirtz's criticism that existing education and training institutions have not kept pace with the demands of the new technology. Hopefully, teaching machines offer one means of attracting and holding in training programs those who might otherwise end up among the "hard core" unemployed.

TRAINING PROGRAMMERS FOR USAA

Jean S. Moye

Jean Moye outlines the historical interest in and development of programmed instruction for use in the United Services Automobile Association. She outlines the manner by which USAA established an in-house capability for producing programs for use in training employees, and the proper integration and management of training using programs.

Interest in programmed instruction at the United Services Automobile Association began with the purchase of machines and programs in punctuation and spelling in September, 1961. Experience during the fall and spring with the machines and programs indicated that, while the material was slanted at a little lower level than we would have liked, training was accomplished with a higher level of final proficiency in a shorter period. Also, less time of the company training director, who was the instructor, was involved.

To supplement its introductory information, the USAA staff continued to read all available material in the field. In September, 1962, the decision was made to embark upon a rather sizeable exploration to determine the applicability of these techniques, not only in our industry, but specifically in our own organization. Based upon advice from many authorities in the field and our own knowledge of our particular needs, USAA decided to develop an in-house capability, and to employ consultants to train company programmers. The staff expected to gain a great deal from training subject-matter experts familiar with company procedure in the techniques of programmed instruction. USAA was fortunate in being able to take advantage of the availability of consultants who were in San Antonio.

With our plans to enter the field of programmed instruction, major decisions had to be made. First, a plan to canvass our employees to determine those who might be considered or selected as programmers had to be devised. It was decided to stimulate curiosity and motivation, so an open test was announced. A programmed instruction exhibit was prepared in a classroom, and all employees were welcomed to come and familiarize themselves with programmed instruction. The exhibit was displayed for three days. Nearly all company employees examined this exhibit. Some employees could see immediate uses of some of this material for their children. An effort was made to stimulate thinking by inviting employees to consider how they would feel learning the next higher level job in their department, or acquiring additional knowledge for promotion, by this method. This opportunity had not been perceived by the employees at all. The programs displayed had made an impression, but they couldn't perceive their usefulness at this point.

Finally, employees interested in taking the tests for possible consideration for a pilot unit were invited to report to the cafeteria after hours on a certain date. More than 200, or about 15% of the employees, reported on the day of experimental testing. Ages ranged from 17 to 55, and positions ranged from file clerk to top managerial positions, representing a good spread in ages, background, experience, and knowledge of the company. The battery of different tests was given and scored and a composite score developed to rank, in order, the 200 employees. The consultants reviewed the personnel files and the performance records of the top 35 on this list. Twenty-five employees were selected to begin intensive training.

The day-to-day work operation of the company was not to be interrupted. The 25 employees were asked to come on a volunteer basis on Saturday mornings from 8 to 12 for training for a period of approximately 8 weeks. Homework and additional study was to be done on their own time after working hours.

The consultants came for the original indoctrinations and the inauguration of formal training. The scope of the material and the general instruction areas covered included: lectures on the history of programmed instruction, fundamentals of programmed instruction, techniques of program writing, and methods of program evaluation. The trainees then moved into some practice in writing objectives, criterion test items and frames. Techniques of cueing, fading, and copying were taught and practiced. Evaluation of frames by pre-test and post-test scores and error count was taught.

The first evaluation of the 25 trainees was made to determine those who had the most promise of becoming effective program writers. After six weeks, the first cut-back was made, reducing the group to 17. During the next six weeks, 7 trainees withdrew for various reasons. The program-writer trainees were put in a study-work application situation from almost the beginning. By the third week, they were beginning to produce some programmed materials. The quantity of the work produced by these people was so great that the editing and review of this material consumed a great deal of the consultants' time. At the same time, quality was beginning to appear. The remaining group, consisting of 9 programmers and one editor, had produced 7 usable programs, and had 16 other programs in progress. At this time, the group had to be reduced to 6 programmers, due to budget limitations, with three trainees returning to their previous jobs but remaining on stand-by.

During this initial period, many peripheral training areas were explored, in order to increase the understanding of programmed instruction within our organization. Consultants and program representatives were concerned not to embark on projects so esoteric that the line organization and top management of the company would be unfamiliar with this technique and thereby possibly offer some resistance or hesitancy in either allowing programmed material in their areas, or by not cooperating or proffering information and technical help.

To insure proper use of programmed instruction, it was felt that outside training for supervisory and management personnel was essential. Staff people were encouraged to enroll at the two local universities, at which the consultants were teaching classes in methods of programmed instruction. In this way, they were not embarrassed, nor was their prestige in any way affected when they were included in general orientation classes with the program writers themselves. These staff people were assigned to the two universities, with the higher level people in one course and the line supervisors and the department heads in a course at the other university.

A concentrated effort was also initiated to establish a current library in the field of programmed instruction. Some of these materials were placed in the employee library, and the remainder in the training director's office. The specific technical training for the programmers, and the general orientation for the supervisory staff and managerial people, were the component parts of an overall two-pronged approach to properly launching programmed instruction at USAA. This approach would be assured of understanding and support on the part of top management and the line supervisory staff, while ensuring that the program writers would be proficient and competent to carry off their part of the project.

After the programming unit was organized, a shakedown period brought out some rather interesting points. First of all, several transitions had to be made. Trainees had been selected for their role of program writer on the basis of their background, experience and their subject matter knowledge of the operation of the company. They were to use their subject matter knowledge to avoid repeated interruption, annoyance and dependance on the line people, the real technical experts, for every piece of information. Program writers were told to make use of the subject-matter material acquired during their time with our organization, but they were no longer to be the subject-matter experts per se. They were to be experts in the techniques of program writing, but their material was to be referred to technical experts for validation and technical correctness of the material to be taught. On the other hand, these staff personnel and technical experts were not to encroach upon a writer's style or technique in writing the program. This resulted in a rather significant shift of emphasis for the programmers.

Another very revealing experience was to observe the reaction of these people who had come from highly organized, highly oriented interdependent production units, and who were now stepping across the line into an unfamiliar area where they were completely independent producers. A great deal of responsibility was placed upon these people to be creative and imaginative in a way which they had not experienced before. They had some difficulty in giving up the security and safety of a highly organized, structured work environment, so a deliberate effort was made to break up old patterns. They had no rigid lunch schedule, no timed coffee break. By intentionally dis-orienting an organized pattern, it was felt that these programmers were given an important assist in stepping over the line into the area of independent thinking, and acceptance of responsibility for a project.

At this time, the unit was comprised of seven women. Two young men included in the college program, who had been through the training program, were on stand-by until budget or other indications permitted an increase in the staff. There were problems of temperament and personality. The plans were to develop programmers as individuals and to give them full rein to discover their capabilities. The restraints of rigid schedules have been removed. This was dis-orienting for a time, but natural team relationships are developing. One programmer worked with another programmer on one project and then the team changed to another project. This has proved effective in providing scope, depth and versatility. This flexibility allows a combination of talents to complement themselves to produce the kind of programs USAA needs.

After only six months, members of top management became very pleased at the promise that programmed instruction held. They found that it had applications in new areas. They also found that some possible applications of programs are not significantly more effective or less expensive than conventional training methods. No programs will be developed in these areas.

One of the most important by-products of this project has been the effect on our supervisory force in their more critical examination of some of the operations in which they have been involved, and a fuller recognition of what some of their training problems are and have been. Now, there is a very keen desire on the part of the supervisory staff to discuss how they can help get those employees trained in a shorter period of time.

Our present thinking and plans regarding the implementation and administration of completed programs call for classroom presentation of programmed instruction packages, under the control of the training director and the supervisor of the programmed instruction unit.

Future plans, reached after deliberation of the many factors involved, call for the following: (1) For the next one to two years, it is essential that all possible feed-back from student employees be obtained, so that programs can be modified if necessary. (2) Line supervisors ought to be relieved of as much of the training load as possible. Not every supervisor is a trained instructor, and would need, in addition, special training to administer program packages. (3) New employees, after the usual orientation on the first day of employment, can be easily put in a classroom situation to work through programs developed for the particular department and position for which they were hired. When reporting to the unit supervisor, new employees are then prepared, to whatever degree we have programmed, to begin the new job better equipped to perform productively in a shorter period of time. (4) Candidates for promotion, after selection by the supervisor, will be referred back to the training director, for administration of whichever programs are considered applicable for the particular upgraded job.

USAA feels the above outlined program will greatly enhance the understanding of the role and effectiveness of the training director, the program writer and the line supervisor, and, in addition, will hasten the time until the program becomes operational and of practical value to the company.

This company is moving rapidly in the production and use of programs for training. It hopes to be in the forefront with those who are producing valuable, worthwhile, competent materials within a short period of time for the whole industry.

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APPLICATION OF AUDIO-LINGUAL PROGRAMMING TO INDUSTRIAL TRAINING

Robert Brink

An audio-lingual program was developed for use in training operators to give telephone numbers to inquirers. The programmed course achieved a 40% reduction in training time, 52% increase in passing scores and an 85% increase in perfect scores.

Before I get into the body of my remarks let me say that I am not an experimental psychologist. I have had neither training nor experience in that field. It is not my desire, therefore, to take sides with respect to the conflicting theories. My purpose, rather, is to share with you some of the experiences that we had in developing a course for training information operators in the General Telephone Company of California.

Now the popular concept is that an information operator's job is quite simple. She is required only to look in the directory and report the number if she finds it. If she does not, she so informs the customer. However, in the metropolitan Los Angeles area an operator has six directories containing over 2 million listings to which she may have recourse in searching for any particular listing. Furthermore, she has a daily supplement for each directory showing new listings and changed listings.

In addition, as you can understand, customers rarely ask for listings precisely as they are worded in the records, so there is necessarily a great body of practice which our operators must be taught with respect to search procedures, questioning techniques and reporting. In this regard, it might interest you to know that in the Los Angeles Central directory there are some 3,500 listings for the name Johnson alone. Yet our objective is to provide a report acceptable to the customer within less than 40 seconds, on the average, from the receipt of his order. In fact, 20 to 30% of the numbers are quoted by the operators within 15 seconds. This emphasis on speed may seem excessive. However, let me remind you that information service is a non-revenue-producing service. Its provision costs over $2,000,000 per year in our California company alone. So, taking the 40 second average disposition interval as a guide you can see that any training approach which could result in reduction of this average by only one second would produce a savings of $50,000 annually. Furthermore, the grade of service acceptable to our subscribers and to the Public Utilities Commission of California, will not tolerate an error factor higher than 1.7%. Since an operator will handle in excess of 600 calls per day in a busy office she cannot make errors of any type on more than 10 calls if she is to achieve the accuracy factor we demand. Therefore, I think you can realize that we are caught between a Scylla and Charybidis of providing a high grade of service on one hand and doing so economically and extremely quickly on the other. So the complexities of information services are far greater than might appear at first blush.

The question became then, how could the learning or training situation itself be manipulated to produce the maximum transfer to the job situation? It is generally accepted that in any specific application the transfer is improved by increasing the amount of similarity between the training situation and the job situation. In our situation we were faced with the fact that our principal requirement is for vocal contact between an operator and customer. After some consideration and study we felt that the use of tape recorded instruction was more nearly realistic to our job situation than an effort to do the same programming in written form.

In the design of our course, we attempted to establish "task set" by frequent use of such phrases as "suppose a customer were to make the following request," thereby giving meaning to each problem and establishing a realistic matrix within which to consider its solution. We made liberal use of what I call "walk through" calls during which we took a student step by step through the procedures necessary to arrive at a proper report. The characteristics of these calls have been very carefully designed to help a student establish criteria by which to judge her subsequent decisions. Then we provide extensive practice calls with the complexity of the recall required quite low for each reinforcement. We attempted throughout to provide an optimal schedule for the seeding of review material with the result that there are over 600 practice examples found in the course.

In addition to the lesson tapes themselves, we use other teaching aids including instructor manuals covering equipment operation and training room administration; student work books to provide drill material and listing examples for purposes of comparison; periodic written quizzes, in multiple-choice form, as a check on learning progress; and a classroom analysis form on which to record student progress and completion schedule.

The results that we have achieved with the program have been quite satisfying. In the first place, we have been able to reduce the length of our initial training, and therefore its cost, by 40%. We had used ten days for information training prior to this time, and

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as a result of this course have reduced the training time to six days.

We have now trained 237 girls on the audio-lingual program. One hundred and two of them have completed their three-month probation period. The average personal index in the third month has been 91.2%, we're looking for 85% or better at this point. But more rewarding we have had a 52% increase in passing scores and an 85% increase in perfect scores.

Meanwhile, the quality of service in the offices has greatly improved as students trained under the new method have been absorbed into the force, and cost of providing service has declined. So we feel the program is eminently successful.

We have realized several ancillary benefits from the new course. One has been the standardization of our training, not only among students in one office but between offices throughout our company. This has advantages which are obvious to all of you, principally as regards subsequent on the job supervision and inter-office transfers.

Second, and this is not necessarily intrinsic to the tape recorded type of programming used, we have a ready library of refresher training material which can be given as need arises to experienced operators. Such refresher training or training of re-hires and girls with previous experience can be done concurrently with a new training class, since all students work independently, and without requiring additional instructor time. This has provided an additional savings over and above the initial 40% reduction in training costs.

Third, the instructor, being freed of much of her previous responsibility for teaching routine material, is able to give closer attention to each student's development and is also able to overlap other duties while supervising the training room.

Finally, through standardization of our operator training and establishment of more realistic measures of terminal behavior, I am hoping that we shall be able to contribute to a definitive study of applicant testing with benefit to recruitment and labor turnover.

Let me end my remarks by saying that whatever programming skills we have acquired are not most efficiently transmitted through conference methods. This is particularly true since the success of a program is dependent upon very fine discrimination in technique which are by no means apparent from a study of the completed product. These have been arrived at largely through trial and error.

Like an indulgent parent trying to direct an unsophisticated child, I should like to be able to guide your path to avoid some of the pitfalls through which our experience has led us. I am convinced, however, that contention with these problems is in itself salutary. Unfortunately, programming is still more an art than a science. As such, it must be nurtured and developed through experimentation and practice.

A TECHNIQUE FOR DETERMINING THE ADMINISTRATIVE FEASIBILITY OF PROGRAMMED LEARNING IN GOVERNMENT AND INDUSTRIAL TRAINING PROGRAMS

James E. Gilbert

James E. Gilbert presents a technique for quantifying the feasibility of programming training tasks. The quantification is based on a ranking of each course against four criteria of each administrative feasibility. The rankings are converted to Program Feasibility Scores, which can be categorized and compared either between or within subject matter areas.

In order that any instructional method may be most economically and efficiently employed, it must be determined which training programs would be most suited for its application. Where will the use of programmed learning techniques bring the greatest return for the time, manpower, and money involved? In other words, in what courses sponsored by an industrial or government training organization would it be the most feasible to use programmed learning?

The subject of feasibility is concerned with two areas: administrative feasibility and technical feasibility. Administrative feasibility is defined here in terms of training requirements, difficulty of meeting such requirements, stability of subject matter, and availability of individuals knowledgeable in the subject matter and in programmed learning techniques in order to prepare adequate auto-instructional materials. Technical feasibility, on the other hand, is defined in terms of the training of programmers, programming methods appropriate to the subject matter, display formats, and facilities to evaluate programs. It is the plan of this paper to concern itself with administrative feasibility, leaving technical feasibility (with its myriad problems) for another time.

The specific problem of this paper was to develop a technique which would indicate those courses sponsored by a government or industrial training organization in which it would be administratively feasible to use programmed learning methods. This technique was concerned with both complete and partial programming of courses, in that the administrative critera "hold" regardless of the extent of the course programmed. The question of partial or complete programming more appropriately belongs to the area of technical feasibility anyway.

Operationally, (Gilbert, 1961) administrative feasibility was defined in terms of our criteria a course must meet to be considered administratively feasible to program. (1) Requirement—the number of trainees requiring a particular course. (2) Difficulty—the degree of difficulty in meeting the training requirement now or in the near future due to staffing, fiscal, space, or instructional problems. (3) Stability—the degree of subject matter stability in terms of amount and frequency of revision. (4) Technical Assistance—availability of technical personnel to prepare auto-instructional programs. In general, the technique consists of the following steps. Courses are first grouped by subject matter. It is necessary to have at least five courses per subject matter grouping. If this is not possible, a miscellaneous subject matter area must be created and courses placed in it until an N of at least five is obtained. Responsible training officers then judge each course on the basis of the defined administrative criteria and rank these courses on each of the four criteria. These ranks are converted to a criterion score by comparison with a nomograph (Table 2). The criterion score is then summed across criteria and a Program Feasibility Score obtained. Based on the Program Feasibility Score, a Program Feasibility Category is assigned. The Program Feasibility Category indicates the degree to which a course is administratively feasible. The Program Feasibility Score provides guidance to the training officer in comparing the administrative feasibility of courses. Detailed instructions for this procedure may be found in Table I.

Whenever possible, multiple rankings of courses on the four criteria should be obtained. When the judgments of more than one training officer are available, a Program Feasibility Score is determined for each course, for all judges. These Program Feasibility Scores are then averaged. The average Program Feasibility Score for each course is then treated as if it were a PF Score based on only one judgment and assigned a Program Feasibility Category. Obviously, scores based on the judgments of more than one knowledgeable training officer are more reliable.

For purposes of example, consider two subject matter groupings: (1) mathematics and (2) office practices. The courses have already been grouped by subject matter. These courses will be found listed on a Program Feasibility Worksheet (Figure 1) by subject matter. In the first four columns to the right of the course title appear the criteria ranks of the courses on the four criteria. "Introduction to Modern Algebra I" for example, ranks sixth on requirement, fourteenth on difficulty, tenth on stability, and ninth on technical assistance. "Key Punch Operation", on the other hand, ranks first on requirement, fourth on difficulty and stability, and third on technical assistance. Continuing to the right, consider the next five columns. These are the criteria scores. The ranks have been converted into criteria scores by using Table 2. Let us find the criteria score for "Introduction to Modern Algebra I", requirement rank 6. Table 2 is entered vertically by finding the total number of courses ranked (16) and horizontally by locating the rank of that course on the specific criteria (6). Where the low (6) and the column (16) intersect the criteria score (66) will be found. This process is followed for all courses in both subject matter areas. When criteria scores are entered for all courses the sum of these criteria scores is computed by adding the criteria scores for the four criteria for each course. This is the Program Feasibility Score (PF Score). The PF Score for "Introduction to Modern Algebra I" is 170, while for "Key Punch Operation" is 200.

After the PF Scores have been computed, they are compared with the right-hand column of Table 3 and the proper Program Feasibility Category (PF Category) is assigned by checking one of the five appropriate columns to the right. By counting the checks in each column (1 through 5) the number of courses in each PF Category may be determined. Table 4 indicates the frequency of courses in each category by subject matter (mathematics, office practices). Inspecting the results of the application of this technique to the two subject matter areas in question, mathematics seems the most probable to consider programming, at least administratively, and within that subject matter area the following courses are the most administratively feasible: "Elementary Algebra", "Calculus I", "Caculus II". This example has been presented as the result of the judgment of one training officer. It is hoped that, in the majority of applications of this technique, the judgments of a number of training officers will be used. If multiple judgments had been used, the PF Scores for each course would have been averaged and this average PF Score treated in the same manner as a single training officer PF Score.

Table 1

Instructions for Determining the Administrative Feasibility of Programmed Learning

Step	*Instruction*	*Outcome*
1.	Group courses into subject matter areas (must be at least five courses in each subject matter area).	
2.	Make appropriate entries on the *Program Feasibility Score Worksheet* under "Subject Matter Area" and "Course Title" columns.	
3.	Rank each course in the subject matter area on the four administrative criteria to obtain criteria ranks.*	CRITERIA RANKS
4.	Convert the criteria ranks to criteria scores using the *Criteria Rank Conversion Table* (Table 2).	CRITERIA SCORES
5.	Sum the criteria scores for each course to obtain the program feasibility score (PF Score). (Where multiple judges are available, average the PF Score for all judges and continue with step 6 using this mean score.)	PROGRAM FEASIBILITY SCORE
6.	Compare the PF Score with the *PF Category Score Bounds Table* (Table 3) to assign each course a program feasibility category (PF Category).	PROGRAM FEASIBILITY CATEGORY
7.	Indicate the PF Category for each course by placing a check in the appropriate box on the worksheet.	
8.	Continue this process until all courses in all areas have a PF Score and PF Category. Compare PF Category frequencies across areas and PF Scores across courses to determine the courses and areas most feasible to program.	

* In assigning ranks use the numeral 1 to signify that course with the largest training requirement, that course with the greatest difficulty, etc. As the courses decrease in training requirement, difficulty, etc., the ranks should be of greater magnitude. Tied ranks are not permitted. A decision must be made and all courses must have a different rank on each criterion.

The rationale concerning the technique proposed, some pertinent remarks concerning the steps in the application of the technique, and the derivation of some of the tools used by the technique will now be discussed. The criteria of administrative feasibility were limited to the four defined, as those are the most specific to both programmed instruction and government or industrial training. Two notable exceptions to the criteria are money and time. These were not included as some fiscal considerations are subsummed under difficulty and technical assistance while others are taken care of by budgeting for conventional training courses normally administered. Time factors, although important, were considered as a constant as time normally is allocated to course preparation regardless of the method of teaching employed. In the judgment of training officers and psychologists, the four criteria stated are the most relevant to the concept of administrative feasibility.

Certain remarks are pertinent concerning the steps followed in determining the programming feasibility of courses. When the courses are arranged in subject matter areas, five is a required number, as this is the smallest group that can be assigned criteria scores meaningfully. Ranking courses on the four criteria in groups less than five tends to be too artificial and assigning scores from a nomograph to such a small number results in criteria scores that are spuriously high. As stated earlier, courses that cannot be placed in a subject matter category can be grouped together into their own category and judgments made in terms of this miscellaneous group. When ranking the courses on each of the four criteria, all data available to the training officer should be used. Planning documents, budget programs, manpower estimates, trainee requirements, in terms of skills and numbers, should all be considered. The more objective data available upon which to assign ranks to different courses across criteria, the more meaningful will be the resulting Program Feasibility Score.

Converting the ranks to criteria scores was included in order to be able to compare course program feasibility

PROGRAM FEASIBILITY WORKSHEET

Subject Matter Area	*Course Title*	*Criteria Ranks*				*Criteria Scores*				PF	*PF Category*				
		Reqr.	*Diff.*	*Stab.*	*Tech.*	*Reqr.*	*Diff.*	*Stab.*	*Tech.*	Score	*1*	*2*	*3*	*4*	*5*
Mathematics	Elementary Algebra	1	1	1	15	97	97	97	9	300		√			
	Intermediate Algebra	15	2	2	14	9	91	91	16	207			√		
	Fundamentals of Math.	8	9	5	16	53	47	72	3	175			√		
	Ele. of Math. Anal. I	3	5	12	7	84	72	28	59	243			√		
	Ele. of Math. Anal. II	4	6	13	8	78	66	22	53	219			√		
	Calculus I	7	10	3	1	59	41	84	97	281		√			
	Calculus II	9	11	4	2	47	34	78	91	250		√			
	Intro. to Modern Alg. I	6	14	10	9	66	16	41	47	170			√		
	Intro. to Modern Alg. II	13	15	11	10	22	9	34	41	106				√	
		5	12	7	4	72	28	59	78	237			√		
							22	53	72	163				√	
	Matrix Theory	2	4	1											
	Intro. to Complex Variable	11	8	15	12	22	35								
	Vector Analysis	12	7	16	13	28	59	3	22	112				√	
Office Practices	Basic Typing	4	1	1	2	30	90	90	70	280		√			
	Advanced Typing	2	2	2	1	70	70	70	90	300		√			
	Key Punch Operation	1	4	4	3	90	30	30	50	200			√		
	Office Procedures	3	3	5	4	50	50	10	30	140				√	
	Refresher Shorthand	5	5	3	5	10	10	50	10	80					√

Figure I. Mathematics and Office Practices Program Feasibility Worksheet

across subject matter areas. Converting to criteria scores also has advantages in treating the data, interpreting the data meaningfully, and putting the data into a form that is more appropriate for empirical study. It was important to consider the type of studies that will be carried out in the future and apply a technique that could easily be adopted to future needs.

Rankings were converted to criteria scores by using the formula (Ward, W. H. 1961):

$$\text{Criteria Score} = 100 - \frac{100\,R - 50}{N}$$

Where: R = Rank assigned to a course.
N = Subject matter area size.

Table 2

Criteria Rank Conversion Table

This table converts rankings to a criterion score scale with a mean of 50. To use the table, first determine the number of courses ranked. Then enter the table with the rank of the individual course on the criterion (a rank of 3 indicates a course that is third from the top). At the intersection of the row and column will be found the criterion score.

	Number of Courses Ranked																
Rank	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*Rank*
1	90	92	93	94	94	95	95	96	96	96	97	97	97	97	97	98	1
2	70	75	79	81	83	85	86	88	88	89	90	91	91	92	92	92	2
3	50	58	64	69	72	75	77	79	81	82	83	84	85	86	87	88	3
4	30	42	50	56	61	65	68	71	73	75	77	78	79	81	82	82	4
5	10	25	36	44	50	55	59	62	65	68	70	72	74	75	76	78	5
6		08	21	31	39	45	50	54	58	61	63	66	68	69	71	72	6
7			07	19	28	35	41	46	50	54	57	59	62	64	66	68	7
8				06	17	25	32	38	42	46	50	53	56	58	61	62	8
9					06	15	23	29	35	39	43	47	50	53	55	58	9
10						05	14	21	27	32	37	41	44	47	50	52	10
11							05	12	19	25	30	34	38	42	45	48	11
12								04	12	18	23	28	32	36	39	42	12
13									04	11	17	22	26	31	34	38	13
14										04	10	16	21	25	29	32	14
15											03	09	15	19	24	28	15
16												03	09	14	18	22	16
17													03	08	13	18	17
18														03	08	12	18
19															03	08	19
20																02	20

Score Bounds of PF Categories

PF Category		*Percentages*	*PF Score Bounds*
1	Definitely program	15	313 or above
2	Probably program	20	249 to 312
3	Question	30	153 to 248
4	Do not program	20	89 to 152
5	Definitely do not program	15	88 or below

Table 3

Frequency of Mathematics and Office Practices Courses in PF Categories

PF Score	*PF Category*		*Mathematics*	*Office Practice*
313 or above	1	Definitely program	0	0
249 to 312	2	Probably program	3	2
153 to 248	3	Question	6	1
89 to 152	4	Do not program	3	1
88 or below	5	Definitely do not program	0	1

Table 4

The formula produces scores ranging from 0 to 100 in a rectangular distribution with a mean of 50. The standard deviation varies with N due to the rectangular distribution. A rectangular distribution rather than a normal distribution was used due to the fact that with ranks, an equal number of cases falls within each category, each of the four criteria must have the same number of cases at each rank. Table I is the result of carrying out the computation of the formula for groups of courses from five to twenty.

In establishing the Program Feasibility Category, the percentage distribution in Table 3 was used for the PF Score for each of the five categories; these percentages were also used to establish the score bounds for each of the five categories. The lowest PF Score that can be obtained by any course is 40, where the size of the subject matter area is five and the rank is five on all four criteria. The highest score obtained for this same subject matter area is 360, a rank of 1 on all four criteria. The total score range, therefore, is 320 score points (360-40) and this with a mean of 200 (4x50). Multiplying this score range by the percentages the score bounds reported on Table 3 are obtained.

At the present time, the percentages used (15, 20, 30, 20, 15) represent only best judgments based upon limited observations. They must await empirical validation studies before they can be used as anything more than approximate guidelines. If different percentages are desired, either more of less rigid, they may be substituted with minimum difficulty, requiring only a change in score bounds. With these considerations in mind, only a course in the upper 15% could be very seriously considered as administratively feasible to program (PF Category 1). Those courses falling in the next 20% (PF Category 2) could be challenged while those in the middle 30% (PF Category 3) could be very seriously questioned if considered for programming at all. Courses in the lower 35% of those judged were so low as to preclude consideration (PF Categories 4 and 5).

After identifying the most feasible subject matter area the training officer may then select within that area the courses of greatest promise. Knowing which courses are of high administrative feasibility, the training officer is in a much better position to make judgments concerning what may now be properly called technical feasibility. The government or industrial training organization is also in a position that will allow it to plan more adequately for effective, efficient and economical application of programmed learning methods to training functions.

DETERMINING TRAINING NEEDS

Joseph M. Madden, Major, USAF

Joseph Madden discusses the need for detailed specifications of training needs and course objectives, not only for programmed instruction, but for all other types of instruction as well. He also discusses a combination procedure for developing a "behavioral task statement," based on detailed task-analysis and serving as a solid basis for the development of training materials.

The objective of a training program may be stated as teaching people to respond in a certain way in a given situation, that is, to perform certain required work at the time it is needed. In order to attain this objective, a cycle is followed which delineates four large divisions of activity. These divisions are: determination of training needs, design of training curricula congruent with these needs, presentation of the training to people, evaluation of the training given in terms of the curricular objectives, and, to begin the cycle again; determination of additional training needs.

All phases of the cycle are important. The effects of improperly accomplishing any one phase results in failure of the entire training effort. The man is not adequately prepared for what he has to do, he has been overprepared, and money has been wasted in giving him training which he does not use, or the timing is off and he is trained too long before the training is needed or not soon enough. Following this line of thinking, it quickly becomes apparent that the salient focus for most efficient and economical training should be on that phase of the cycle concerned with determining training needs. An overstatement of needs results directly in excessive costs. An understatement of needs produces results similar to erroneous practices in the other three cycles so that man cannot do the required work effectively.

Not only does an emphasis on cost control make the determination of training needs extremely important, but this part of the four-phase cycle has historically been a course of considerable difficulty concerning which very little progress has been made. We have learned much about curriculum design and the training itself, less about training evaluations and still less about the technology of accurately determining training needs. Since we are dealing with a four-phase cycle, the success of which depends upon efficient accomplishment of each phase, it seems appropriate to direct attention toward the weakest of the four.

The determination of training needs may be broken down into two distinctly different types of activity. The first is describing the work activities to be done by the individual to be trained, and the second is inferring the training needs from this description.

The description of the work to be done forms the keystone not only of the training program, but every phase of personnel management. Every aspect of the training program is directly dependent on the accuracy and comprehensiveness of the work description. In spite of this, describing work, usually in terms of units called jobs, has been treated generally in a rather casual manner. A paragraph or two of descriptive material is even considered as adequate coverage for an entire occupation in some circles. Inference of training needs from such descriptions cannot approach a reasonable degree of accuracy. More detailed and comprehensive information is needed and the information must be in a form which facilitates inference of training needs.

I would like to describe a method used in the Air Force which has been developed to provide the quality and detail of work activity information needed for inferring training needs as well as several other purposes. Although this method is presently unique in the Air Force, considerable interest has been shown in it by the other military services, governmental agencies, and industrial concerns. Furthermore, the method is general in that it can be applied in any situation where work descriptions are obtained.

The Air Force method utilizes a task inventory to survey the work of incumbents in jobs, specialties, career-leaders, or general occupation areas. The task inventory consists of a listing of pertinent task statements organized into categories called duties. Each task statement describes a bit of behavior and an effort is made to keep these bits about equal in size, that is, at the same level of specificity. An attempt is also made to make each task statement descriptive of behavior which is independent of that expressed by other task statements. A prime feature of the method is that the incumbent not only checks off those tasks which he performs, but he writes in additional tasks which he does but which are not listed. In addition, he is requested to rate all tasks which he performs on one or sometimes two rating scales. The dimensions of work covered by the rating scales depend upon the purpose of the survey. Ratings may be concerned with such topics as the relative proportion of time spent on each task, where the task was learned such as on the job or in a technical school, the proficiency level on each task, and so on.

Administration of the inventories usually takes place in a testing room, one of which is located on practically every Air Force Base. The booklets are mailed to testing officers with a list of the number and types of incumbents to whom they are to be administered. The testing officer obtains the desired incumbents through the appropriate commander, administers the inventories, and returns them to the Personnel Research Laboratory for analysis.

The method I have very briefly described is considered a combination of the best features of traditional job analysis procedures. For instance, the open-ended feature of the questionnaire method is retained by providing the opportunity for writing in task statements, and interviews and observation of work being performed may occur during construction of the inventory. The task inventory method is simple, provides work information in a standard, qualified form accurately and comprehensively, provides current information, permits inexpensive broad sampling, serves many using agencies, and is flexible in terms of sample selection. A good deal of research has been completed and reported in the course of development of the task inventory method and much of the rationale is supported by factual findings.

The end result of a survey utilizing the task inventory method is a list of tasks performed by incumbents in the occupational unit surveyed. Each of these tasks is described in terms of a number of variables, depending on the purpose of the survey and the rating scales used. If the determination of training needs has been one of the objectives of the survey, various kinds of pertinent data would be available. These would include such items as the proportion of incumbents who perform each task, whether the task was learned on the job or in the schoolroom, whether or not incumbents feel a need for more or better training for each task, and so on. We thus have a very complete behavioral description of what the training program is intended to prepare people to do, barring abrupt changes in the work content. We have avoided vague and often meaningless statements such as, "must have knowledge of . . ." or "must be able to . . . ." Our task statements are clear and concise. We are now ready to approach the task of making inferences concerning the training needed to accomplish the work tasks we have listed.

With regard to the inference of training needs, it should first be pointed out that the nature of the behavioral task statement reduces or may even eliminate much of the difficulty involved in determining training needs. For instance, if the task statement is, "Remove and replace C-47 engine," the training objective is not difficult to state. Requirements for knowledge of theory or principles, of course, are dependent upon inferences that are not simple, but this is true in any system. If the scope of work covered is narrow, the task of inferring training needs is much simplified. That is, if the task inventory covers only a single job such as, pastry cook, or battery maintenance man, a large number of complications are avoided which must be dealt with when larger work units are used. In most cases, however, a larger unit such as a whole occupation, or specialty as it is called in the Air Force, is the subject of concern. Specialties contain a varying number of jobs at all levels of skill, from helper to superintendent. The specialty is the unit of Air Force management and practically all personnel actions are based on it. It corresponds to what is often called a job in industry. Let us list just a few of the more dominant problems resulting from the fact that a rather large work unit is employed.

The first problem, which concerns the specialization-generalization controversy, is not unique to the Air Force. It seems to be of general concern, even for small organizations. We usually settle this one in a vague and tenuous way. We say something about "broad job concepts" and end up attempting to prepare the individual to perform all the work in a specialty at the apprentice, journeyman, or supervisory skill level and often at all three skill levels. We are then immediately faced with another general problem, "What is to be learned in the classroom and what on the job?" Most of us have some sort of of an approach to this question which draws a line between theory, principles, and general information on the one hand, and skills, practice, application, and implementation on the other. The third problem in this general area is the temporal application of training, determining the experience points at which to provide for further, higher level training. We could spend a great deal of time on each one of these three problem areas and they merit our concerted attention, but I point them up here primarily to clarify the proposition that even when good occupational information is available, we must infer training needs relative to a specific set of behaviors, to be applied in school or on the job, at a fairly precise point in the development of the individual incumbent. These three determinations must be made and clearly set forth as a matter of policy guidance.

It might be mentioned that on-the-job training is almost always very difficult to administer, control, and evaluate and offers a promising application of programmed teaching techniques as a supplement to instruction received from supervisors.

Once the educator knows the training objectives in terms of behaviors to be produced in individuals and where the training is to occur, as well as its temporal application, he is ready to infer from the desired behavior statements exactly what it is which he must impart to the student. Notice that the ultimate test of his success will remain the same as his original objective, which is the behaviors in the task list which are performed by the student after his training has been completed. In other words, there is invariance in the criterion, the behavioral task statement is the basis of determining training needs as well as the criterion for evaluating the training after it has been given. Inadequacies in the training program may stem from either inaccurate inference of the training needed or from ineffective administration of the training. We might provide the wrong training very efficiently or the right training very poorly. With the task statement as a beginning point as well as an end-point, the difficulty of inferring training needs is reduced and it becomes possible to pinpoint the source of inadequacies in the training situation itself.

CONSIDERATIONS WHEN ORGANIZING PROGRAMMING PROJECTS

William J. Knight

William Knight discussed the problems of achieving standardization and quality of programmed materials and avoiding redundancy in the preparation of programs through proper organization. He concludes that centralization of programming is necessary until more qualified programmers are available to achieve proper decentralization of functions to achieve better customer service.

INTRODUCTION

As a member of management, I am concerned about the growth of the Programmed Instruction (PI) movement. All of us connected with the movement should have one overall objective; make sure that the P.I. movement achieves the status of a major industry. One factor that will ensure this objective is the development of quality programs.

In the last few years, most organizations developing programs realized that the programming task (writing frames) was only 25% of the total development cycle and even if done well did not necessarily mean a quality program would result. In many cases, this recognition has resulted in the development of better programs by exposing the effects different types of organizational designs can have on the quality of the program.

This paper will explore the *Centralized* and *Decentralized* organizational designs for the primary purpose of examining the effect on program quality.

ORGANIZATIONAL DESIGN AND PRODUCT QUALITY

Figure I illustrates the structure of a centralized organizational design, i.e., one Training Division to satisfy all the PI requirement of the Military Electronics Division and the Commercial Electronics Division of KAL Industries.

Figure 2 illustrates how the structure of KAL Industries would change if a decentralized design were selected, i.e., both divisions have their individual autonomous training departments.

Availability of qualified programmers/programmer trainees has been a major factor in the selection of an organizational design. It is quite obvious, there is no easy method to develop individuals who can eventually do a creditable programming job in a reasonable amount of time. Because of this programmer shortage, many companies have been forced into the centralized design even though a decentralized design would be more efficient if the manpower were available. North American Aviation, Inc., a decentralized corporation,

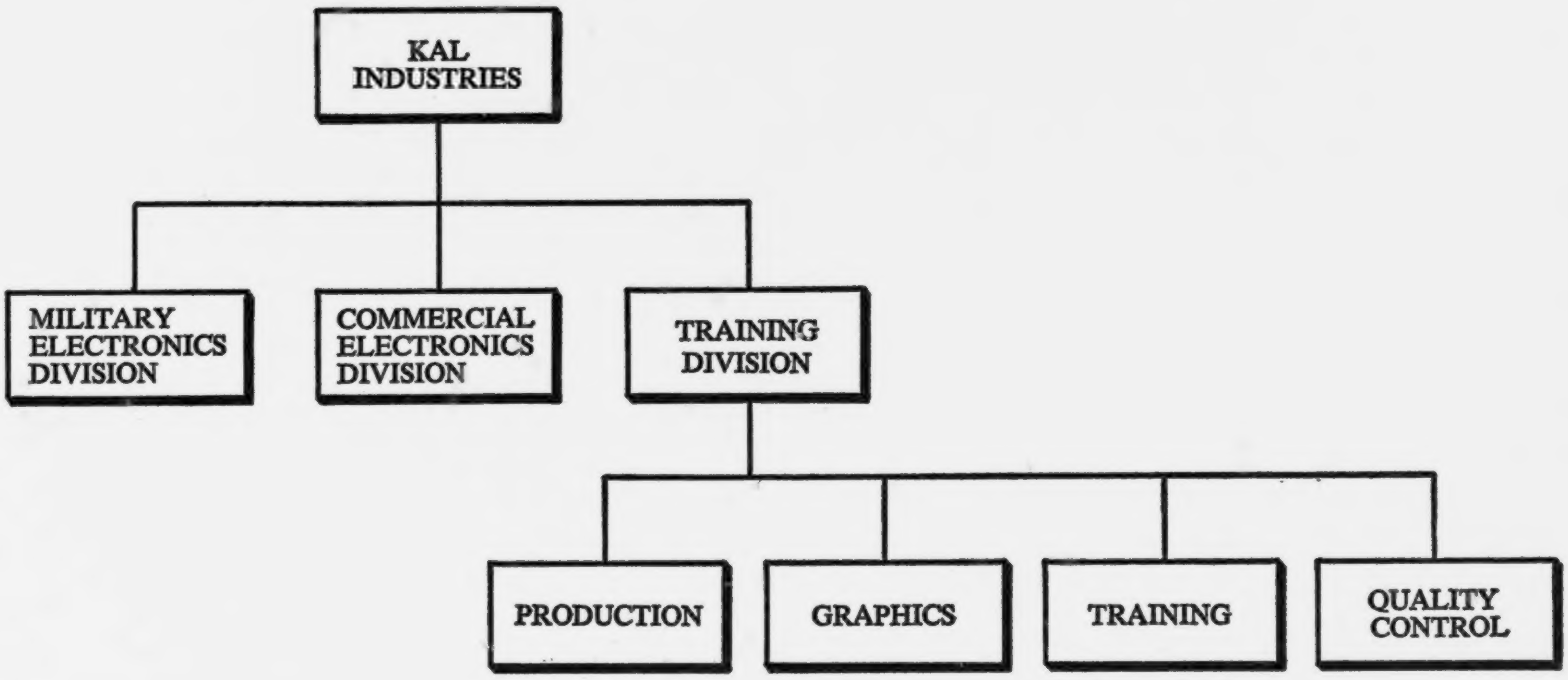

Figure I—Centralized Design

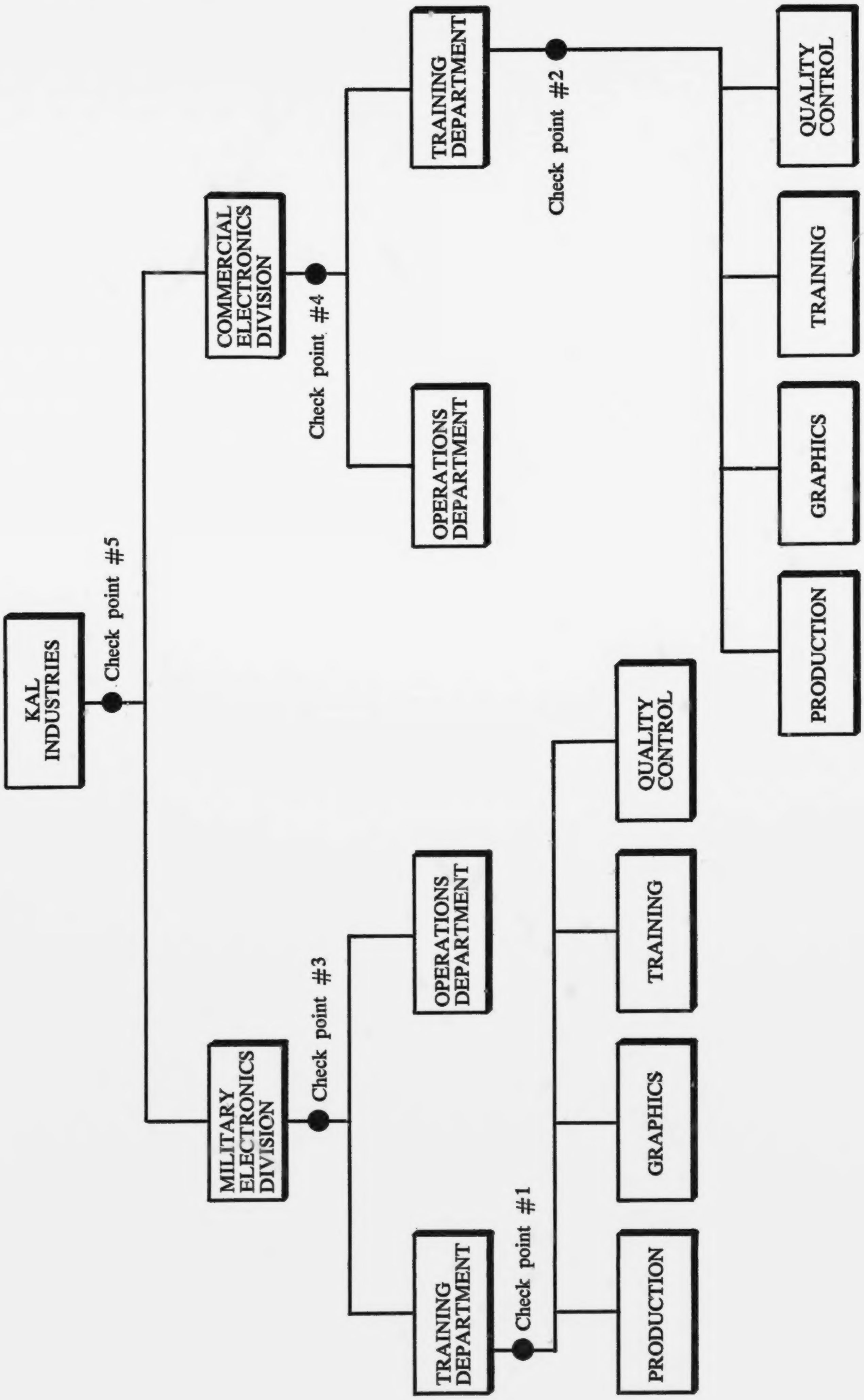
KAL INDUSTRIES
Check point #5
MILITARY ELECTRONICS DIVISION
Check point #3
TRAINING DEPARTMENT
OPERATIONS DEPARTMENT
Check point #1
PRODUCTION
GRAPHICS
TRAINING
QUALITY CONTROL
COMMERCIAL ELECTRONICS DIVISION
Check point #4
OPERATIONS DEPARTMENT
TRAINING DEPARTMENT
Check point #2
PRODUCTION
GRAPHICS
TRAINING
QUALITY CONTROL

Figure 2

initiated a programmer training project which included the training of several already qualified training specialists. One reason why this project worked was because the programmer trainees had *training know-how* before their PI training class started.

After training many programmers over the past two years, Training Systems, Inc. (TSI) has found a high correlation of success between qualified trainers and successful programmers. This should not be surprising since a job analysis of the programming function specifies a requirement to know basic training principles in addition to programming principles. Too often in the past two years people have specified criteria for selecting programmers without first doing a detailed job analysis of what the programmer actually does when working. This has caused many people to believe that a writer (technical, fictional, etc.) could become an "instant programmer" as long as he liked to work in a closet for eight hours a day. It should be obvious to all training directors that a programmer must know the fundamentals of training or teaching. Once a writer has acquired a training knowledge the writer *may* be able to learn programming. This is also true for astronauts, engineers, accountants, secretaries, etc.

The major advantages of a centralized organizational design (one Training Division, i.e., PI function) are as follows:

1. Ease of control
2. Better utilization of available programming manpower
3. Uniformity of policies

Ease of control occurs when the number of check points is decreased.

In the decentralized design of Figure 1, Training Department (TD1) operates completely independent of TD2. Since the subject matter for commercial electronics is similar to that of military electronics, the possibility of producing redundant programs is high. The centralized design of Figure 1 makes this redundant programming highly unlikely since there is only one Training Department.

The uniformity of policy characteristics stems from the fact that all policies are made by one person. This means that the quality control standards will be consistent with the overall image of the company. It is quite possible that the two training departments shown in Figure A could have two different sets of testing procedures. One procedure might state that validation must be accomplished by using large numbers of students. The other procedure may use small numbers for validation. This inconsistency cannot occur in a centralized organization.

CONCLUSIONS

At present, and mainly because of the labor shortage, a centralized organization can best guarantee the production of quality programs. As more trained personnel become available, decentralized designs may be a more efficient and effective method of developing programs. Time will tell.

VII Military and Governmental Applications*

PROGRAMMED INSTRUCTION BREAKTHROUGH IN AIR FORCE TRAINING??

James E. Briggs, Lt. General, USAF (Retired)

The USAF Air Training Command, which General Briggs commanded at the time this talk was presented, is probably the largest training institution in the world. As such it is constantly on the alert for new methods of training more men better, cheaper, and faster. In an effort to improve training technology they have trained more than 300 programmers and have already achieved savings in training by this experimental effort. This has been described as "the largest of all automated teaching programs." At the same time the Air Force has conducted familiarization courses for managers so that any traditional resistance to change might be alleviated. Early results in the areas for which programs were produced were most gratifying both in cutting training time and increasing amount of material learned. Although the final evaluation of programmed instruction as the breakthrough in training technology has not yet been made, the Air Force is committed to give it a fair trial. This is in line with the precedent set by all the services in taking the lead in experimenting with new training technologies.

The mission of the Air Training Command is expressed by its motto, "Prepare the Man." Our function is to meet the Air Force's training requirements for a myriad of weapons systems. Not many years ago we could turn out an electronics technician for the F-80 with only ten weeks of training. A squadron needed seven of these men. For the F-106 squadron, we need 70 electronics technicians, and most of them must spend more than a year in electronics training before they carry their own weight. Furthermore, F-106 support men in five specialities must be taught basic electronics for their jobs.

Examples like this could be quoted for all the technical fields used in the Air Force including the missiles, the communications equipment, and the many subsystems that make them work. Each advance increases training time by requiring that more things be taught and learned which in turn increases the cost of training and training equipment.

Our job involves people—and it's a big job. Last year we trained over 362,000 airmen at a cost of approximately 700-million dollars. As new command and control systems approach operational status, our training requirements will become more complex. We have made many improvements in our training procedures and management techniques, but we are constantly concerned with the Command's ability to meet the Air Force training job of the future. We must constantly revise our training concepts, methods, and procedures to meet tomorrow's mission in terms of cost, timely production of trained personnel, and quality of graduates.

Our concern with these future problems caused us to establish what we called our Path Finder Study Group in October 1961. This was a group of senior Air Force officers, who conferred with some of the most outstanding civilian scientists in the country during their study. This group thoroughly examined some of the technological advances affecting our training mission. In doing so, they identified the need for a number of changes in our methods of operation. These changes included a shift in our training capability from primary dependence upon resident technical schools to a more evenly balanced system of resident and extension service. Another change was the development of a management system that would provide faster reaction in controlling the student flow. Still another change required us to develop training technologies centered on individual learning rates rather than on group learning rates.

Prior to the Path Finder Study Group's recommendaitons, we had begun to investigate the possibilities inherent in programmed instruction in the Air Training Command environment. Path Finder not only endorsed our action but encouraged us to expand our experimental effort. We decided to accomplish this investigation in two phases. Phase I was to be an experimental application of programmed instruction to a select and heterogeneous group of courses, and Phase II would consist of expanded use, if the results of Phase I warranted such action. Our Phase I activities will soon be completed. Our preliminary results, however, have been most gratifying. Under our concept of concurrency, we already are establishing plans to implement Phase II.

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* Editor's note: The USAF programs mentioned in this section are experimental and developmental in nature and are not at this time available for general distribution.

We feel that this action will be more than warranted by the results that we have already received from Phase I.

Our most immediate problem in establishing programmed instruction was to develop an in-house capability. Since November 1961, the Air Training Command, through contract with outside agencies, has trained more than 300 personnel throughout the Air Force in the techniques of developing programmed materials. Although it has been said that this effort more than doubled the number of instructional programmers in this country, our capability is still minimal when one considers that we have more than 2400 training courses. My advisors inform me that, were we to exploit our present capability to its maximum, we could not program more than 5% of the Air Training Command effort within the next three years.

In addition, realizing that we would encounter the usual resistance experienced by those introducing a relatively new instructional methodology, we provided orientation and indoctrination in programmed instruction to more than 1500 supervisors and training managers. This effort was very important in producing the cooperation and support necessary to an evaluation of this effort.

At present, we have more than 100 programmed instructional packages in use or in the process of being developed. These materials cover subjects ranging from "T-37 Emergency Procedures" in flying training to "Precision Measuring Equipment" in technical training.

Our general objective is to determine whether a programmed instructional package in lieu of, or as a supplement to, conventional methods of training will substantially improve the quality of our graduates and materially decrease the costs. Concretely, we have specified that for a program to be acceptable, 90% of the students must score 90% or above on a comprehensive test covering all of the course objectives.

Our preliminary results show that we are on our way to reaching our 90/90 objective, with reductions in training time of 25-50%. One of our programs has reduced our training time as much as 83%. At Chanute Air Force Base, for example, we programmed a six-hour block of instruction in "Basic Hydraulic and Pneumatic Principles." This programmed course took only one hour on the average for students to complete and, at the same time resulted in a gain in performance of 20%. At Keesler Air Force Base, programming reduced the training time for an introductory AC&W radar course from fifteen hours to five hours, with 95% of the students scoring over 85% on the criterion test.

A program developed at Amarillo Air Force Base on the use of hand tools raised the average level of achievement by 33% with a 40% reduction in training time. The test for this package was a job performance test—the actual use of hand tools in a realistic job environment, not a paper-and-pencil exercise. At Sheppard Air Force Base, a program on reading and interpreting electrical diagrams is producing students who score 16% higher than those taking conventional instruction and with an average saving of 36% in training time.

Such decisive results have caused us to look very hopefully to our Phase II efforts.

We have not been content to simply develop our in-house capability. We have tried to exploit as many facets of programmed instruction as the current state of the art would permit. Our training centers have reviewed off-the-shelf programmed materials relevant to their training mission. We cannot afford the luxury of duplication.

Another area we have been exploring for the use of programmed materials is in our on-the-job training programs. The frequent equipment modifications in our complex defensive and offensive weapons systems require constant training of our personnel. Since many of these technicians are in remote or inaccessible areas, programmed materials could be produced centrally and made available before equipment modifications actually occurred. At least one programmed on-the-job training package is under development at each training center.

I could go on to describe our many other activities related to the exploitation of programmed instruction, such as our effort to bring together programmed instruction and instructional TV, the use of synchronized audio-visual devices, and many others.

Although this methodology is still young and many problems associated with its use are yet unsolved, we are certain that it will have many applications to our training requirements. We do not, of course, claim that programmed instruction is the answer to all our problems. We do feel that extensive use of this technique, under appropriate conditions, will help us to meet our training requirements faster, with less cost, and at the same time provide the using commands with more thoroughly trained personnel. We feel that programmed instruction many result in the emergence of a true educational technology with valuable implications for educational institutions, industrial organizations, and the armed services.

Since World War II, the armed services have spearheaded movements in instructor training, audio-visual devices, closed and open-circuit TV, and language laboratories, to mention only a few of the techniques which have been explored. We shall continue to investigate any technology that may alleviate the training problems created by technological growth.

We have under way plans to establish a model experimental classroom for conducting pilot studies and demonstrations of new educational techniques. We can use this classroom to evaluate automated teaching and audio-visual devices, to demonstrate classroom management problems, and for instructor training. It will also provide facilities for controlled experimentation in various instructional techniques.

Even beyond these continuing developments, we must remain alert for future breakthroughs in educational technology. We rely on, and will continue to maintain close liaison with, educators, research institutions, industrial concerns, and the other armed services. We realize that all of these groups are actively concerned with these problems.

It is obvious that projected command and control systems will create problems in the scope and complexity of training. As automation and systems complexity increases, the tasks assigned to human control increase in difficulty. Our task is to train the man to do his job efficiently.

Will programmed instruction be the breakthrough in Air Force training? I don't really know as yet. I do know this, however; that nothing has appeared on the horizon which has given us a more hopeful sign for such a breakthrough as has programmed instruction.

It was Ralph Waldo Emerson who said that the reward of a thing well done is to have done it. I am not saying that we have already done it. The next year or two will demonstrate, more than anything I can say here today, whether we have done it or not. We are convinced that we have conclusively demonstrated that it *can* be done. Whether it will be done or not is going to depend to a great extent on the willingness of many of our training managers and training staff to find ways of implementing those things that we have demonstrated could be done. This is, in and of itself, no easy task. I do not feel that we can confidently erase the question marks which follow the words "programmed instruction" and "breakthrough" until we can look around us throughout the Air Training Command and find it a common sight to see students going through a variety of programmed materials, each proceeding at his own optimum pace, each achieving his own maximum quality performance in the shortest possible period of time with the minimum assistance needed from a master instructor, and all at a minimum of cost. Even when this is a common sight, we must still continue to be alert to new ways, new methods, and new ideas.

Whether programmed instruction does or does not provide us with the promised breakthrough remains to be seen, but out of our efforts in experimenting with it has come a new appraisal of our training efforts, a new way of looking at the wide question of how should we best go about doing our training task. This, I am confident, will remain with us and for this I am grateful.

MECHANICAL TRAINING WITH THE K-38 REVOLVER

Jackie Lang, TSgt, USAF and J. E. Melton, TSgt, USAF

In this paper, Sergeants Lang and Melton discuss their efforts in developing an instructional program for teaching both verbal and motor skills. The program they prepared resulted in a 35% reduction in training time, with trainees achieving better than 98% of the seven comprehensives verbal and motor skill objectives.

When the authors began programming the mechanical training package for the K-38 Revolver, we immediately looked for guidance in existing linear programmed packages. A multitude of programs were available whose terminal behaviors were the listing of verbal terms and concepts, but there was no guidance in the form of published programs whose terminal behavior involved non-verbal, motor or performance of skills.

How does one program the performance of a skill? As neophytes to programmed instruction we welcomed any and all suggestions, for ours was a difficult task. We should like to share with you some of the problems we encountered in performing this task of programming verbal and non-verbal terminal behaviors.

Before discussing the problems which arose, let us look at the objectives of the program for mechanical training for the K-38 Revolver. The objectives range from the simple naming of parts to the performance of a manual skill. Specifically, a summary of the objectives is as follows. Upon completing the program, the student should be able to:

1. Identify and name each of the 30 parts of the K-38 revolver
2. Describe the mechanical function of each part
3. Disassemble and assemble the revolver
4. Clean and lubricate the revolver
5. List the corrective action to be taken if a malfunction occurs

To prepare the student to display these behaviors we were allotted four hours. This was the same amount of time allowed for traditional instruction. Here are the techniques we used and the problems we encountered in programming verbal behaviors.

The revolver consists of thirty separate parts. We had to prepare the student to recognize each of the parts by its shape, to name each part, and to describe its function. The student was introduced to each part by referring him to an 8x10½" illustration, which depicted and named that particular part along with three other parts. We then stated the function of the part and required the student to respond overtly to incomplete rules and examples.

Originally the program was filmed for use in the Dukane Redi-Tutor teaching machine. The illustrations were placed in a separate booklet which required the student to shift constantly from machine to booklet. This wasted too much time. It also permitted easy access to heavily cued introductory illustrations during criterion frames. We then decided to publish the program in textbook form for further testing. The illustrations were included in the textbook and were far more satisfactory.

The Ruleg System was used throughout the program. The student was often required to view diagram, and other illustrations to complete the responses. These illustrations constantly exposed him to the parts locations and their shapes. Criterion frames require the student to name a part, describe its function, and identify the part in a panel. Diagrams and illustrations were used extensively in this program.

In hopes of conserving material, a separate response booklet was prepared. In addition to increasing the length of the text, use of a separate booklet decreased the effectiveness of the program since a vast amount of time was wasted leafing through both of the books. The program was later revised so that the responses could be written in the text.

Although considerable success was realized through this type of programming, the students encountered some difficulty when asked to describe the function of the revolver's internal parts. To strengthen this part of the program, we realized that the actual weapon must be included. Use of the K-38 revolver permitted the student to observe the mechanical function of each actual part in relation to other parts. For example, after the student was conditioned to respond, "the hand rotates the cylinder," he is then told, "cock the weapon and observe the hand's movement in performing its operations." Use of the actual weapon may not follow any known linear programming techniques, but we found it effective. Students were able to respond correctly during criterion testing.

Use of the weapon was also necessary in the programming of non-verbal behavior such as the actual disassembly and assembly of the weapon. However, the revolver was not used in the early developmental stages of this portion of the program. Some of the students were able to demonstrate disassembly and assembly skills although the weapon was not introduced until testing. To insure that all the students could perform the task, the revolver was included early in the program.

Use of the weapon presented problems. Students were frequently required to write a response and perform a task in the same frame. For example, a frame would read, "turn the front side place screw _____". The responses desired were, first, write the response, "counter clockwise", second, physically turn the screw. This type of frame disturbed the student since he had to decide which action to perform first. Though the problem seems minor, it caused us much grief. It was finally resolved by writing a separate frame for each of the responses. Another problem was that frames requiring students to perform a task lacked reinforcement. For instance, when the student is conditioned to respond "the first part to be removed in revolver disassembly is 'the front side plate screw' ". The next frame merely tells him to perform this step.

It is after this performance step lack of reinforcement occurs. To strengthen responses of this nature, illustrations were included to show the part that should have been removed and what the revolver should look like after the part had been removed. This simple step seemed to provide the necessary reinforcement. Once the actual revolver was utilized in the program and manual skill responses were reinforced, the program was highly successful.

If there has been one significant finding in programming of this type, it is this: The tools and equipment which are required to perform a task must be included in a program to insure its success.

Upon the completion of the development of the 268 frame linear text as described above, the program was field tested under operational conditions on three separate groups of trainees totalling 53 students The program resulted in a 35% reduction in training time, from 150 minutes to 98 minutes, with trainees achieving better than 98% effectiveness on both the written and performance criteria tests.

AN EXPERIMENT IN PROGRAMMING THE CARE AND USE OF AIRCRAFT MECHANICS' HAND TOOLS

Lewis L. Coleman, SSgt, USAF

SSgt L. L. Coleman describes what has been considered the most popular programmed text in the Air Training Command study of experimental programmed materials. This program not only teaches nomenclature and the application of hand tools, but also includes practical experience in the use of hand tools in the simple tasks on the jet engine. The experimental group showed gains over the conventionally taught control group on both the written and performance tests.

In the Jet Engine Mechanic Course at Amarillo Air Force Base, instruction in the care and use of common hand tools is introduced in the second day of the course. Instruction includes nomenclature, physical characteristics, care, and application of hand tools such as wrenches, pliers, screwdrivers, sockets, thickness gages, torque handles, etc. Instruction is of the conventional type utilizing discussion, demonstration, two training films, and a student text. Training also includes practical experience in using about 50% of the tools by performance of simple mechanical tasks on a jet engine.

This instruction was considered satisfactory, but an experiment was conducted to see if the training objectives could be more effectively accomplished by use of an automated instructional program.

A 302 frame linear-type program was developed with the following stated objective: The student will be able to care for and use the hand tools commonly used by a jet engine mechanic.

About 75% of the frames contained illustrations.

> The nut below will tighten since it is being turned ....
>
> (Illustration)

> All the nuts and bolts on jet engines are right hand thread. They turn clockwise to tighten and .... to loosen.

> Use the hinge handle and socket to loosen nut again. Retorque to 185 inch pounds. Your setting should look like this:
>
> (Illustration)

> Using a hinge handle, extension, and ½ inch socket, loosen the nut in area "H".
>
> (Illustration)

To provide practical experience for the students in selecting and using tools, eight identical trainers were designed to be used in conjunction with the program. Throughout the package there are frames directing the students to select and use tools to accomplish simple tasks provided by these trainers.

Evaluation of the program was accomplished by comparing results of written and performance tests administered to a control group of 52 students receiving conventional instruction and an experimental group of 52 trained by the program. Students participating in the evaluation project were regular input airmen having an age range of 17 to 22 years and an average education of 11 years. The two groups were carefully matched by selection on the basis of mechanical and general aptitude scores, and by educational level. The matching of the two groups was within 99.8% accuracy.

The Jet Engine Mechanic Course has a weekly student entry which necessitated the use of seven classes to provide a total of 104 students. As each class entered training, it was divided to form the control and experimental grouping with approximately eight students in each group. During the period of seven weeks the control groups were taught in the conventional manner. Each class had a different instructor.

The programmed instruction experimental groups of approximately eight men each were trained in a separate area. Each week a monitor was assigned to the experimental group to provide each student with a programmed text, a trainer and a tool kit. The monitor also maintained a record of the time required for each student to complete the program. The students were given no assistance in using the program.

There were two tests used in the evaluation, a fifty question written test containing verbal conceptual items and a performance test covering skills in using tools.

The two tests were used as a pre-test one day before training, as a post-test one day after training and again for retention after 30 days. The tests were administered and scored by two instructors and two clerks who were associated with neither the conventional instruction nor the programmed package. During testing, all students in both groups were intermixed so that the examiners did not know to which group the students had been assigned.

The statistical results of the testing are as follows:

COMPARISON OF CONTROL GROUP & EXPERIMENTAL

	Pre-Test	*Post-Test*
Control Group 52 Students	6-63	45-77
Experimental Group 52 Students	6-56	59-98

Group written pre- and post-test results. Possible score 100.

Table I

COMPARISON OF AVERAGE TIME

Control Group 52 Students	5 Hrs 10 Min
Experimental Group 52 Students..	3 Hrs 21 Min

On the written pre-test the control group averaged 32.5% as compared to 32.7% for the experimental group. On the post-test, however, the control group averaged 63%, a gain of 93.9% as compared to the experimental group which attained 84.2%, a gain of 157.7%.

The performance test showed smaller differences between the groups. The control group averaged 61% on the pre-test and 82% on the post-test, a gain of 32.2%. The experimental group averaged 59.2% on the pre-test and 86.8% on the post-test, a gain of 46.4%.

Both groups were tested with the same tests 30 days after training to determine retention. The results of the retention testing are not considered valid because hand tools were used repeatedly during the 30-day interval. A slight gain in retention scores of the control group indicates additional learning was possible. The very slight drop by the experimental group was from a higher grade plateau with a higher total net gain beyond the pre-test scores.

The time required to teach "Hand Tools" by the conventional method is 5 hours and 10 minutes. The average time to complete the programmed package was 3 hours and 5 minutes with a time spread of 2 hours to 4 hours between the fastest and slowest students.

After completion of the evaluation of this program, the package was revised and further testing shows that almost nine out of ten students reach over 91% of the training objectives.

From this experiment we can conclude that this programmed package can teach knowledge items more effectively than conventional instruction and also accomplish the instruction in less time. Of particular significance is the fact that a programmed package can very effectively train students in simple manual skills.

THE AIR FORCE LETTER

John D. Hathaway, MSgt, USAF and Dannie M. Gillham

John D. Hathaway and Dannie M. Gillham were trained as programmers during Phase I of the Air Force's extensive program development project. They wrote a program designed to teach basic Airmen both the knowledge and skills required to type a mailable Air Force letter. This paper describes the procedures they used in evaluating and revising the program through three classroom tryouts. They have much to offer in the way of practical suggestions.

The Air Force Letter program is designed to replace an eleven hour lesson in the Administrative Specialist Course. Generally speaking, the program teaches the same material now taught conventionally in the course.

The first question to be answered was whether the performance part of the lesson would be programmed. In the conventional course, three or four class periods are devoted to presenting the academic portion of the lesson and the remaining seven or eight periods are used by the students to type the actual typing problems listed on their work sheets. The authors could have programmed only the information needed by the students to type the work sheets. In this case, the students would have begun the work sheets as soon as they had completed the program.

A decision was made to attempt to teach the whole lesson in one program. Once the decision was made to program the entire lesson, none of the authors would settle for any type of criterion test that did not require the student to type a mailable Air Force letter. The test devised consisted of three problems which required the student to demonstrate his ability to type an Air Force letter on both preprinted and plain stationery and a second page continuation for either type of stationery.

At this stage of the project the lesson was outlined. This outline was made in detail so that very little additional work was necessary when the writing of the frames was begun.

For the first try at writing frames, each of the three authors attempted to write one third of a particular topic. This system was rejected because when the three individually developed sets of frames were brought together it was very difficult to fit them into a meaningful whole. The system finally used called for each writer to devise a set of frames for the same small segment of the program. When all were ready, a joint session was used to discuss the three sets of frames and decide on the best mode of attack. Then, the best parts of all three were combined into the final program.

This method prevented any one writer from getting too far afield before being drawn back on the track by the other two, while still providing several sets of ideas on each segment.

As soon as each main segment of the program was finished it was tried out on individual students. Luckily, the student obtained for the first trial run was quite bright and very articulate. As he went through the frames which had been set up on 3 x 5 cards he made many helpful comments. He suggested use of simpler terms, pointed out gaps in the material presented, and indicated military jargon not familiar to most of the students. After this trial, a number of changes were made in the program.

An average student was used for the next tryout. At this time, the first two main segments of the program were tested. This student was not as helpful as the brighter, first student but still made some worthwhile suggestions which were used to improve the program.

A student from the lowest portion of the class was used for the third tryout which consisted of the first three main segments. Communication with this type of student was much more demanding. It was difficult to gain his confidence and to draw out his comments. The main accomplishment was to identify frustration frames. Although an attempt was made to determine what caused the frustration, in most cases the student was unable to identify and explain the trouble. However, these frames were worked over by the authors with an eye toward simplification and better continuity.

This general process was continued until the entire program was completed. Once the entire program had been tested, several students were used in individual tryouts. At this time arrangements were made for the group tryouts.

During the period when the final arrangements were being made for the trials, a good deal of time was spent in working out the ground rules under which the trials would be conducted. Some of the stipulations were as follows:

1. No student in the control or experimental groups would be permitted to attend remedial training during this period.

2. No student of either group would be permitted to take any training materials out of the classroom at the end of the shifts.

3. The instructors in the experimental classes could give no help to the students—the program was to stand alone.

An instruction booklet was designed for the experimental class instructors, giving detailed instructions as to how the class was to be conducted. A similar, though somewhat smaller booklet, was designed for the control class instructors. These were similar to the type of instructions used to administer Air Force tests such as the Airman Qualifying Examination.

The student population consisted of both male and female airmen who had been in the Air Force for only a few weeks. Their average age was 19 and most of them had graduated from high school. They attended school on one of three six-hour shifts which began at 6 A.M., 12 Noon, and 6 P.M.

The students in the experimental group averaged 82% correct frame responses. On the post-test, the experimental group averaged 59 correct answers out of a total of 78 raw score points or 76% while the control group average was 67 out of 78 or 86%.

These results caused the authors to take another long look at the program. Although all frames were reviewed, emphasis was placed on those to which less than 90% of the students responded correctly. Some material was deleted from the program entirely in cases where it wasn't taught in the conventional course and was not useful in ordinary daily work. Some frames were arranged in a different sequence; some frames were added to close gaps in the presentation of the material; some terms were simplified; some awkward sentences were rearranged, etc.

Knowing that the first tryout would turn up some needed changes, the lack of control in the testing situation was ignored. However, certain changes were made in the tryout procedure prior to the second tryout. The criterion test was revised because it was discovered that the manner in which the problems had been stated was causing misinterpretation by both the conventional and program students.

For the first trial, the classes which would take the post-test after having been taught by the conventional method were identified early. The instructors were briefed as to the ground rules and told that the experiment was being conducted to determine the effectiveness of the program in contrast to the conventional methods they had been using. Course personnel were aware of the content of the post-test for some time and the post-test was in the course building for six or eight hours before the test was to be given. Grading was done by course personnel.

The second group tryout was performed in such a manner that the conventional instructors did not know that their classes were to take the post-test until the day the test was given when the tests were delivered to the course. This time the students in the experimental group averaged 93% correct frame responses. On the post-test, the experimental group had an average of 39 out of 47 total raw score points or 83%, while the control group average was 42 out of 47 or 89%. This was an increase of 7% for the experimental group but only 3% for the conventional group. It appeared that the program was now teaching about as effectively as the conventional method.

A review of the response sheets for the frames involving typing indicated that the students were unable to evaluate their work effectively. Due to this finding, another tryout was arranged with the provision that the instructor help the students as needed with special emphasis on the first of the nine complete letters that the students type in the two booklets of frames containing the performance part of the program. The test results of this class were better. The students in the experimental group averaged 95% correct frame responses. On the other post-test, the experimental group had an average of 43 correct answers out of total of 47 raw score points or 91% while the control group average was 42 out of 47 or 89%. At this point the programmed instruction package was performing very slightly better than the conventional method.

In the conventional classes, eleven 50-minute periods are devoted to the Air Force letter. This is 9 hours and 10 minutes total time. The experimental group on the first group tryout took an average of 9 hours to finish the program. In the second group tryout, the average time was 8 hours and 13 minutes. In the third group tryout the average time was cut to 7 hours and 28 minutes when the instructor was permitted to assist the students.

The following three conclusions seem to be appropriate, based on the results of this experiment: There is an advantage to permitting the instructor to help the students. Rigid controls are necessary in order to obtain meaningful results from experiments. Existing manuals can be used to advantage in devising programs by reducing the number of frames required and concomitantly helping the students become familiar with the use of the manual on the job after they leave school.

PROGRAMMED INSTRUCTION AT CHANUTE AFB, ILLINOIS

Robert F. Harris

Robert F. Harris outlines the mission of Chanute Air Force Base and discusses the application of programmed instruction in comparative tests with conventional instruction. The author lists the comparisons which show significant increase in student achievement at the same time training time is substantially reduced.

Chanute Air Force Base is located in East Central Illinois approximately 120 miles south of Chicago and approximately 20 miles north of Champaign, Urbana, the home of the Universtiy of Illinois. Chanute Air Force Base, Illinois, is known throughout the United States Air Force and the armed forces of many countries. The 3345th Technical School at Chanute conducts over two hundred resident courses, and it has a field training team of approximately 600 instructors who take training to specialists at their permanent duty stations. The Technical School has a staff of technical writers who prepare an equally significant volume of manuals and instructional materials for use by USAF officers and airmen as a part of their on-the-job training and self-improvement programs.

The scope of the training program at Chanute is diversified to an extent that graduates may be assigned to any one of the major air commands of the Air Force. In operation at the present time is a diversified and complex group of courses that provide individual training for officers, airmen and Air Force employees who will become members of the personnel sub-system for such weapon systems as the B–52, KC–135, B–58, GAM–77 IM–99 and the Minuteman.

With the preceding brief description of the environment in which we have worked with programmed instruction, the remainder of my comments are about how we have used programmed instruction and on certain observations we have made during our limited experience with it.

The first professional formal training for our personnel selected to become programmers started in January 1962, just a little over a year ago. Training for some of our programmers started as recently as September 1962.

In the absence of established and universally accepted criteria for selection of programmer-trainees, approximately twenty-five individuals were selected, on a purely subjective basis, to receive the training. The recommendations of the individual's supervisor and such guide lines as retainability, professed interest in the new techniques, and knowledge in certain technical areas in which units of instruction were to be programmed were observed to the extent practicable. The list included offcers, airmen and civilian personnel.

The selection of units of instruction for the programmers to program was a cooperative effort that involved personnel from Headquarters Air Training Command, the Chanute Technical Training Center, the School, The School Department and the programmer-trainee. A list of the units of instruction to be programmed is shown on Chart 1. This is a list of Programmed Instruction Packages (PIP's) that we at Chanute refer to as our prototype or first generation PIP's.

Our prototype PIP's were or are being developed under a team concept in which two or three programmers serve on a team responsible for programming a given unit of instruction. For comparison purposes, the second generation PIP's are to be written with just one programmer assigned on each team and he will be

Units of Instruction to be Programmed
PIP:
Basic Hydraulic & Pneumatic Principles, 6 hrs, Linear
Property Responsibility, 8 hrs, Linear
Principles of Pitot-Static Systems, 9 hrs, Linear
JP 42350, Part A: Warning Systems; Part B: Batteries & Their Maintenance
Gyroscopic Principles, 4 hrs, Linear
Aircraft Familiarization, 4 hrs, Linear
How to Study & Principles of Learning, 16 hrs, Linear
Aerodynamics, 6 hrs, Branching
Aircraft Oxygen Systems, 6 hrs, Branching
Observing, Recording & Encoding Visibility & Obstruction to Vision, 7 hrs, Branching
Interpolation for Determination of Dew Point, 7 hrs, Branching
Maintenance Data Collection Reporting, 17 hrs, Linear
General Principles of Test Construction & Construction of Multiple-Choice Items, 7½ hrs, Linear
Principles of Automatic Transmissions, 12 hrs, Mathematics
Jet Engine Compressor Section, 6 hrs, Linear

Chart 1

encouraged to consult and counsel with other programmers as the need arises. In referring to our second generation PIP's, we refer to a list of units of instruction to be programmed by a programmer who has served on a team of two or three programmers that has completed a prototype PIP.

Several of our first generation PIP's have been completed to the initial satisfaction of the programmer and are being used in a comparative study. In the comparative study we are comparing the performance of a control group of students with the performance of an experimental group of students. The control group has received instruction on the unit of instruction by the "conventional" method and the experimental group has received instruction on the same unit of instruction by PIP. The control group and the experimental group for a given unit of instruction are administered the same pre-test, post-test and retention test. In each case, the tests are composed of items mutually agreed upon by the conventional instructor, the programmer and an instructor supervisor. Chart 2 contains data that are typical of data collected in the comparative studies of our first generation PIP's

In our second generation PIP's, greater emphasis is being placed upon these three functions:

1. The objectives for the unit of instruction, must be stated in measurable terms of observable student behavior, developed as a team effort and released to the conventional instructor and programmer alike by a training manager. The team that develops the objectives for the unit of instruction must include a training supervisor and a programmer.
2. A criterion test must be developed and approved by a training manager. The criterion test must be comprehensive, testing the student's performance on each of the behavioral objectives.
3. Given a list of behavioral objectives and a comprehensive criterion test, both of which have been

Chanute TTC
Tryout Data

	PIP	*Conventional*
Pitot Static Systems		
Linear, 297 Francs		
Students	43	46
Pre-Test Scores	26%	28%
Post-Test Scores	92%	71%
Range of Post-Test Scores	62-100%	38-92%
Average Time	3:05	6:45
Aircraft Oxygen System		
Branching, 217 Frames		
Students	52	48
Pre-Test Scores	54%	55%
Post-Test Scores	88%	77%
Range of Post-Test Scores	78-100%	22-84%
Average Time	4:30	4:30
Basic Hydraulic and Pneumatic Principles		
Linear, 126 Frames		
Students	38	40
Pre-Test Scores	57%	55%
Post-Test Scores	82%	75%
Range of Post-Test Scores	53-100%	30-80%
Average Time	1:16	4:00
Gyroscopic Principles		
Linear, 237 Frames		
Students	47	47
Pre-Test Scores	41%	38%
Post-Test Scores	83%	73%
Range of Post-Test Scores	53-97%	47-90%
Average Time	2:46	3:30
How To Study		
Linear, 328 Frames		
Students	48	41
Pre-Test Scores	27%	19%
Post-Test Scores	92%	60%
Range of Post-Test Scores	80-100%	37-83%
Average Time	2:39	4:30
Principles of Learning		
Linear, 289 Frames		
Students	48	41
Pre-Test Scores	20%	22%
Post-Test Scores	90%	56%
Range of Post-Test Scores	66-100%	20-91%
Average Time	3:35	7:30
Aerodynamics		
Branching, 201 Frames		
Students	26	20
Pre-Test Scores	63%	67%
Post-Test Scores	97%	94%
Range of Post-Test Scores	81-100%	73-100%
Average Time	2:27	4:30

Chart 2

approved by a training manager, the programmer prepares the PIP. The standard of performance for the PIP is that at least 90% of the target population will achieve at least 90% of the objectives.

In some respects, our use of programmed instruction so far might be described by the casual observer as an effort that has produced results that are less than spectacular, and to those of us who have worked closely with the programming project, the experience that we have had with our first generation PIP's has been very satisfying and stimulating. Although mistakes have been made, not one of our first generation PIP's will be considered a failure by the Chanute Technical Training Center programmer team. In each mistake that was made, there was a lesson to be learned by someone. In most cases the lesson that was learned can be applied in our job of improving the experiences of students whose behavior we seek to influence, shape or change.

One final point: We are convinced that our study and limited use of programmed instruction at the Chanute Technical Training Center must be considered a success. The credit for the success of this project goes to the diligent, determined, devoted, skillful and patient programmers with whom it has been my privilege to work.

PROGRAMMED INSTRUCTION AND THE INSTRUCTIONAL SYSTEM AT THE U.S. AIR FORCE ACADEMY

Arthur R. Steiger, Major, USAF and Franklin C. Butler, Jr., Major, USAF

The Air Force Academy has concluded that a system of instruction, developed from a thorough analysis of: (1) course objectives, (2) learning processes, (3) media and materials, (4) methods of presentation, (5) evaluation procedures, and (6) role of the instructor, will result in more effective and efficient instruction. Programming is fundamental to the instructional system as the basic means of communications; programming techniques may be applied to written, oral, or visual presentations. Two courses presented by the instructional system over closed circuit television, basic Aerodynamics and basic Spanish and written programs in mathematics and chemistry have indicated a 25% saving in student time with equal student achievement as compared to conventially taught cadets. "Oral" programming, as used in the instructional system required about 10 hours of instructor preparation, per lesson; written programming required 30-50 hours of instructor preparation, per lesson.

The Air Force Academy began investigating new teaching devices and techniques in November of 1960. Our initial investigation concentrated on closed circuit television, programmed instruction, and accelerated reading techniques. Inevitably, we were drawn into considering all facets of the instructional process. As a result of the promising conclusions from our early investigations a Directorate of Instructional Research composed of active faculty members, was formed in August, 1961.

The Academy has evaluated new teaching devices and techniques, including programming, as they apply to an undergraduate academic institution. The military training aspect of the Academy's program has not been considered up to this point although we recognize that profitable applications may be found.

We have concluded that more effective and efficient instruction will result from a system of instruction. The system used may vary from course to course but in all cases it is developed from a thorough analysis of: (1) course objectives, (2) learning processes, (3) media and materials, (4) methods of presentation, (5) evaluation procedures, and (6) role of the instructor.

Programming is fundamental to the instructional system. It is the most effective and efficient communication technique in the instructional process. The principles of programming apply equally to written, oral, or visual presentations.

Two courses are presently taught at the Academy by means of the instructional system—Basic Aerodynamics to second class (junior) cadets and Basic Spanish, a course in the base education program.

Currently basic aerodynamics is being presented to two groups of 110 cadets each over our closed circuit television system. At the beginning of every lesson each cadet is given a handout similar to a linear program with approximately 30 "frames". The instructor "programs" his oral and visual presentation of the lesson; this material along with the student handout forms a program of instruction. For instance, the instructor may explain how pressure varies in the atmosphere and show a short film clip on the subject. At preselected points the instructor will direct the students to read and respond to a specific frame on the handout. The students respond and immediately check the correctness of their answer against the printed answer. They inform the instructor if they have answered correctly over a student-instructor communications system (Teletest). The instructor evaluates the collective response; if he is satisfied he continues with the instruction program; if not, he may repeat, include other explanatory material (branch), or simply allow more time to cover each point.

After the program of televised instruction is concluded, the student continues to the second part of the handout, also in the linear format, which is a programmed review and reinforcement of the preceding instruction. The student completes this part at his own pace. An instructor is always available to answer questions during this portion of the lesson or repeat any portions of the preceding instruction. In a similar manner, a third part of problems or applications of the lesson material is subsequently completed. The student is permitted to leave after completing parts two and three.

About 10 hours per lesson were required to prepare the student handout, the lesson materials, and the televised presentations. Similar lessons, prepared as written programmed instruction, required about 50 hours of preparation per lesson.

The Basic Spanish course is presented by television over the base community antenna system. The programs may be received in over 1250 family quarters, airmen's dormitories, the base hospital, and several other buildings served by the distribution system. Each participating student was sent a set of materials for every lesson. Each of the 56 lessons, consisting of 50 frames each, is presented twice (at 1830 on the first day and 1645 on the following day) before a live studio audience. The material is presented by a method of "oral" programming, similar to that used in aerodynamics. The instructor speaks the content of each new frame which may be a new word or an expression, offers any explanatory material, asks the class to repeat what he has said, corrects the class response if necessary, shows the printed frame on the screen, and then requires the class to write the frame in the space provided in the lesson materials. The pace of his presentation is dictated by the response of the class, which he can observe closely. After the conclusion of each 45 minute lesson, the student is advised to complete the lesson drill or review which is also part of the lesson material. A programmed review follows every eighth lesson and a programmed test is given during the next period. Each student corrects his own test according to the instructor direction, scores it, and mails it to the instructor for entry on the student's record.

One instructor prepares the materials, supervises the clerical support of over 500 students, and presents the lesson over television. Approximately 10 hours per lesson are required. The course includes a vocabulary in excess of 800 words and is equivalent to one year of high school Spanish.

Both of these courses use the fundamentals of the instructional system; programmed presentations in conjunction with student programs, student-instructor feedback, branching and pacing based on the student response, and student paced drill and review. Both courses rely heavily on the student-instructor relationship and tend to maximize, rather than minimize, the role of the instructor.

The course in aerodynamics was prevoiusly presented to 44 cadets during the fall of '63. The group achieved equal learning (as compared to cadets taught by conventional instruction); the cadets averaged about 25% less time per lesson (as compared to conventionally taught cadets). Standard examinations were given to each group. Scores in the Spanish examinations have averaged over 90% for all age groups, from 3 years of age and up.

The flexibility of the instructional system is illustrated by the fact that it can be adapted to such diverse subjects as Spanish and aerodynamics. The techniques of presentation differ according to the nature of the lesson materials but the fundamentals upon which the techniques are based remain the same.

We have also used conventionally written programs in two courses, for a 12 hour block of statistics included in our beginning mathematics course and for a 13-hour block in our beginning chemistry course. Approximately equal learning was achieved in each case as compared with conventionally taught classes with a significant time savings for the student. The written programs were used as the sole means of instruction in both instances. We are convinced, however, that such programs can be integrated profitably into the system of instruction and become an effective means of presenting certain types of basic materials.

The latter two courses required 30-50 hours of instructor time to prepare one class hour of instruction as opposed to 10 hours per lesson in aerodynamics and Spanish.

We have concluded that programming can be very effective in higher education. It is an unfortunate fact that conventional programming is used sparingly, if at all on most campuses. The reasons for this, however, are fairly obvious; (1) written programs have been proposed by their advocates as primary vehicle of instruction thus pre-empting the activity of the instructor in the learning process; (2) most instructors are reluctant to accept the passive role thus created for them; and (3) conventional programming is complex in terms of manpower, laboriousness, time, expense, and in flexibility of the finished product.

The apparent solution is to enlarge the appreciation of programming as a means of basic communication, simplify the development of programs, introduce flexibility and adaptability into their use, and clearly demonstrate to the instructor how he may use programs profitably to his satisfaction.

We believe the instructional system is a solution which can be applied to any academy situation within a wide variety of physical resources. The initiative and creativity of the instructor is the key to success rather than expensive or elaborate equipment.

PROGRAMMED INSTRUCTION AND ON-THE-JOB TRAINING

W. D. Ceely, Colonel, USAF and Jimmie Green, Lt Colonel, USAF

Colonel Ceely and Lt. Col. Green of the Air Training Command describe the Air Force's development of programmed instruction packages for on-the-job training (OJT). The rapid technological advances in Air Force weapons and equipment demand concomitant advances in training. This report outlines the required OJT concepts, the criteria established to implement them, and the techniques used to evaluate the programs. Programmed instruction is treated as a key component in an extensive geographyically dispersed training system.

As recently as 15 years ago on-the-job training played a relatively minor role in the Air Force training system. Most of the weapons and equipment of that day were basically the same as those used during World War II, except for a growing number of jet-powered aircraft. Training of maintenance and operations personnel presented no special problems.

During the 1950's, changes occurred with ever-increasing frequency. Our entire force of combat aircraft was converted from conventional power-plants to jets. A sophisticated and extremely complex Air Defense system was developed. The groundwork was laid for the space program which got underway in the late 1950's. Throughout the Air Force, complex machines came into use to perform many tasks.

During this technical revolution, on-the-job training (OJT) failed to keep pace. The basic OJT method dates back to the Middle Ages. There is no fundamental difference between the ancient guild system and the method the 20th century computer maintenance technician employs to train his apprentice. During the Middle Ages, the apprentice was trained slowly and carefully under the close supervision of the journeyman, just as he is today.

By 1960 it became apparent that Air Force operational units were experiencing more and more difficulty in developing skilled airmen to operate and maintain the complex new weapons and equipment. Several factors hampered on-the-job training to the extent that it became a major problem. Frequently, the only equipment available for training was fully operational. This placed serious time limitations on the learn-by-doing phase of OJT. The knowledges required for satisfactory performance became more extensive. Fewer operational units had the required classroom space, and even fewer had adequate numbers of qualified instructors. The training publications designed during the 1950's were intended for joint use by supervisor and trainee, but supervisors no longer had the time to provide the personal assistance needed for effective use of these materials. The problem was further aggravated by the fact that it became increasingly difficult to keep the training materials technically current.

To see the problem in its proper perspective, we must realize that every year the Air Force trains about 200,000 airmen in more than 1,000 different specialties by means of OJT. In October 1960, several studies were initiated in an attempt to find a more effective method for conducting OJT. The principal finding of the studies was that the Air Force could no longer afford to use traditional methods of conducting OJT.

Most of the training problems in the operational units were in the area of knowledges rather than skills. There were only two apparent solutions to the problem of knowledge training. All the knowledge could be provided in formal technical schools, or the trainee could use self-study publications during his off-duty time. The high cost of formal training, plus the necessity for removing the trainee from his job, made it impractical to expand formal training.

The outcome of the studies was the development of a new concept of OJT. These were the basic elements:

1. The primary responsibility of Air Training Command (ATC) with respect to the Air Force OJT program will be to provide self-study publications which will provide all the knowledges required for airmen upgrading in each specialty. These will be designated Career Development Courses.

2. ATC's secondary responsibility will be to assist the Major Air Commands in developing job proficiency guides. These guides will contain task inventories and reading references. In some critical skills, test questions and work exercises will be added. The guides will be cellular in construction, so that each command and its subordinate units can provide supplements as required.

ATC's new role in the Air Force OJT system requires a careful approach to the problem of developing effective and inexpensive self-study materials. These following criteria have been established:

1. The subject matter will be limited to fundamentals and basic principles. References to specific items of equipment will be limited to illustrations of basic characteristics.

2. The level of treatment of the subject matter will be directly related to the skill level of the trainee.

3. Each course will be self-contained. The trainee will be studying in his quarters and will not have access to other publications.

4. All material in the courses will be unclassified to simplify handling problems.

5. The courses will provide all knowledges required for upgrading in each specialty. End-of-course tests should be the qualifying examinations for upgrading, as Specialty Knowledge Tests are now.

6. To avoid duplication, material common to two or more specialties should be contained in separate generalized courses. For example, a course will be required on the Air Force maintenance management system. This knowledge is required in several maintenance specialties.

In 1961, the Air Force began a series of experiments in programmed instruction. It soon became apparent that this method of training had a direct application to the self-study courses to be developed by ATC. Programmed instructional materials have two characteristics which make them uniquely suitable for use in Career Extension Courses: *They are self-contained and they are designed specifically for self-study.*

In consideration of the advantages and disadvantages previously described, a project was established to prepare a programmed package on subjects common to all airman specialties. This package will provide training on Security, Ground Safety, the Air Force Publications System, Supply Procedures, Training, and Principles of Supervision. This package has 200,000 potential users each year. Airmen going direct from Basic Military Training to operational units will need all the material. Airmen who have completed technical school and are on OJT for progression to a higher skill level will need all or part of the material for review prior to taking the qualifying tests.

This general package represents the largest known application of programmed instruction principles. It will be followed by other courses on subjects common to a particular group of specialties. As an example, airmen in all missile specialties will need a course on guided missile fundamentals.

The size and scope of the project present some special problems in training management. The diversity of subject matter in the package requires that parts of the project be developed in several Technical Training Centers, each of which is responsible for training in different subject areas. A central control agency was established to coordinate the work of the participating centers, and to exercise quality control over all phases of the work. Lackland Military Training Center was selected to perform these functions.

The extremely large volume of printed matter dictated a requirement for maximum standardization of format. Experimentation was encouraged to determine the best possible format within the established limits of time and funds.

Evaluation will be the most difficult problem. Evaluations of each volume must be based on 3 different measurements:

1. First, the programmed material must be measured against conventional material prepared to the same set of objectives. This requires development of the same course in conventional format. Since all the conventional material is already in existence in other publications, no significant increase in workload is anticipated in developing the conventional course.

2. Next, local tryouts must be conducted to evaluate the suitability of the programmed material for wide-scale use in the field. While this appears to be a relatively simple matter, the large volume of material to be used in formal OJT programs requires that this phase of evaluation be as error-free as possible.

3. Finally, field evaluations must be conducted to compare the programmed and conventional materials and to determine the effectiveness of the programmed materials. For the latter purpose, a system of continuing evaluation must be established.

At this time, the Career Development Course project is slightly ahead of schedule. Criterion objectives have been submitted to the prime center for review and approval, and the follow-on work is in progress. We still have little to report in the way of significant results, but we expect to learn a great deal about large-scale programming from this project. The greatest deterrent to success is perhaps the cautious attitude we have developed toward management of the project. The great potential impact of our mistakes has tempered our experimental zeal. We are encouraged, however, by the thought that we may make a significant contribution by easing the training burden in every Air Force organization and at the same time giving the trainee a publication which is both easier to use and much more effective.

RESEARCH ON AUTOMATED TRAINING AT ELECTRONICS SYSTEMS DIVISION

Sylvia R. Mayer

Will programmed instruction hold its initial effectiveness and motivational characteristics over a period as long as two years? Can the operating equipment of Information Systems be used to automatically train its own operators? Can programmed instruction effectively train management level personnel in decision-making? Answers to these and like questions are being sought by the Air Force Systems Command and progress is reported by Sylvia R. Mayer.

Air Force Electronic Systems Division produces the gigantic Information Systems for Air Force Command and Control Functions. Included in this new class of systems are such familiar computerized wonders as these: SAGE, SAC Control System, NORAD Combat Operations Center, Air Force Control System, Space Track and many less familiar.

These Information Systems differ in their military missions such as command, air defense, aircraft or space vehicle control and military intelligence production. However, the equipment, operations and behavioral requirements of personnel are strikingly similar. The raison d'etre of all Information Systems is the same. They are designed to aid and extend the user's intellectual functions.

A large part of the training research for these systems is being cast in the framework of automated training and programmed instruction for on-the-job training. For this brief discussion I would like to sketch the four programmed instruction trends which have been emerging from our research since its beginnings in 1957. These trends are concerned with:

I. A new technology for implementation of programmed instruction.
II. Types of subject-matter unique to Information Systems.
III. Programming techniques tailored to this subject-matter.
IV. Scope of application.

I. Technology of Implementation.

A. The Teaching Machine as a Part-Task Trainer.

In 1958 we initiated automated training in the SAGE System. The conviction that teaching machines would be useful for on-the-job training in SAGE operations was an outgrowth of several factors. First, an analysis of SAGE operator jobs revealed a large portion to be dependent on intellectual functions. These functions can be part-trained and practiced on teaching machines. (Mayer, 1959b, and 1960b)

A second factor concerned the economics of the SAGE on-the-job training problem. Frequent changes in computer-program procedures and equipment characterize Information Systems. Such system evolution results in heavy training and retraining requirements. Teaching machines could help meet these demands economically. (Mayer, 1959a)

Two teaching machines were provided in two different SAGE sites. One was the Air Force's experimental Subject-Matter Trainer. The other the Navy Autorater. Programs were developed and training personnel given guidance for development of additional programs. The programming technique was of the type introduced by Pressey.

We were interested in several questions. Would the crews continue to use the machine over a long period of time, or was their initial interest due to its novelty? Could the technical content of SAGE jobs be analyzed into the formats permitted by the trainer design? Third, we wanted to see what kinds of administrative and procedural problems might arise such as scheduling, developing materials, maintaining the trainers, etc. It seemed useful to determine if the apparent training value of the devices would outweigh the problems they introduced. (Mayer, 1961)

The results were encouraging. On their own the training staffs worked out a procedure to capitalize on the natural rivalry between three operating crews. Scores from performance on the trainer were recorded and exhibited for each crew, rather than for individuals. Peer as well as supervisory pressure was brought to bear on each individual to achieve 100% scores on the teaching machine.

In addition to fulfilling their primary instructional function these trainers also provided a secondary entertainment function. The obvious gaming features of these devices were readily recognized by the crews. Their entertainment value in conjunction with training is not to be minimized in an environment such as SAGE where boredom and fatigue from homogeneous stimulation can be deadly. (Mayer, 1958)

Records of usage were maintained over two years. Usage continued at a steady rate over this period. Only two real problems were identified. One, the machines could not stand up under the heavy usage. Maintenance was and is a recurring problem. Two, the training staff had difficulty keeping up with the continuous demand for new training materials for the machines.

The conclusion reached was that automated training with teaching machines of this type is useful for operations similar to SAGE. The major lesson learned was that something must be done to automate development of programs, if the full potential of automated on-the-job training is to be realized. (Mayer, 1960a)

B. The Teaching Machine as a Whole-Task Trainer.

The success of this first simple feasibility study led to a more ambitious study. The first study was concerned with automated part-task training—such as learning symbology, procedures, and rules, which were more or less separate entities. The second study was an attempt at automated whole-task training to learn both the background knowledge and operation of the system. An effort was made to program the entire learning task by using a combination of a conventional teaching machine for program control and feedback, plus a SAGE console simulator, plus flash-cards. Programs and machines were developed under contract with American Institute for Research. We tested and evaluated these materials for on-the-job primary position training in one SAGE sector, and for cross-training of operators in another SAGE sector. Subjects achieved test scores equivalent to those of operators with several years experience. Thus, there was no question as to the efficiency of this method from the trainees' point of view. However, from the training administrator's viewpoint just keeping the finished programs, training displays and simulator hardware features updated to match the evolving operational system was a major problem even during the six months of the evaluation. (Shettel, 1961)

C. The Built-in Teaching Machine.

From these two studies and another similarly concerned with automated maintenance training, we concluded that research was required for improved implementation for automated training and programmed instruction in Information Systems. Specifically, we moved away from the concept of using separate teaching machines or simulators with fixed programs. We have initiated a long-range research effort to design into otherwise conventional operational equipment the capacity to automatically train its own operators. (Mayer, 1962)

Current work is seeking to determine and demonstrate through use of a model how the logical functions and mechanisms of the operating task and associated program and equipment may overlap with the functions and mechanisms of the training program and equipment. We are trying to define how to exploit this functional overlap in order that the operational equipment may be used at one time to train operators while at the same time it is used by other operators to perform the primary task. Information Systems all have enormous computing capacity which will be exploited to provide computer-directed training. This long-range research program requires the solution of many problems concerned with computer program decision structure, automation of program design, new computer input-output devices for the training function, etc. Contractual support is being provided by Massachusetts Institute of Technology and Biodynamics, Inc.

D. Computer-directed Training in System 473L.

We are now at the beginning of a new system study in which we are trying out on a small scale the concept of using the operational system to train its own operators. This work is on the new Air Force Control System now in development. We are planning automated training to be presented in part by programmed textbook and in part by the system computer through the system consoles. The training task is to learn to communicate with the system computer in its special query language in order to retrieve stored information from the system data files.

The computer-directed part of the programmed instruction will be stored in the system computer, and be presented at the system consoles. The trainee will respond on the console message composers. The computer-directed portion of training will be automatically generated and scored. Contractual support is being provided by American Institute for Research.

II. Type of Subject-Matter.

A second major area of work concerns the adaptation of programmed instruction principles to a wide sample of the tasks, subject-matters, and skills required in Information Systems.

In addition to the operator-skill training studies I have already noted, we have several projects completed and several underway exploring the use of programmed textbooks for trouble-shooting training of electronic maintenance technicians. (Mayer, 1963, and Weiss, 1960) Contractual support has been provided by Matrix Corporation.

We also are experimenting with the use of programmed instruction for training management level personnel in decision-making. A programmed course was recently developed and tested on the PERT System, the new management technique for program evaluation and review. Contractual support is being provided by Raytheon Company. This project demonstrated the feasibility of using the programmed instruction method for on-the-job management training. We are now working on the plans for a follow-on managers' course called PERT/COST, which is concerned with fund allocation techniques. This is being planned for use throughout the Department of Defense.

III. Programming Techniques.

These adaptations of programmed instruction have generated the need for programming techniques which differ in some ways from the more familiar programming for academic subjects. This fact ties in with our third area of interest: programming techniques.

A. The Model.

The underlying instructional model being automated is different, especially in operator training. Instead of the Socratic model of student-tutor interaction, we are automating the master-apprentice interaction model—referred to in military settings as "over-the-shoulder training." In addition to the more conventional programming methods, we need programs in which the master demonstrates, coaches, guides, points, prompts, redirects the apprentice's performance or requires the apprentice to copy, imitate, match, fill-in, start or finish the master sample.

B. Visual Aids Methodology.

In addition, our programming leans heavily on visual aids methodology. Whenever possible, pictures, graphs, diagrams, pointers, signals, symbols replace words.

C. Testing.

Short test sequences are integrated within all our programs. Pre- and post-test procedures are treated as part of our programmed instruction packages.

D. Basic Research.

To fill our long range needs, we are also sponsoring research on a new approach to programming. Contractual support is being provided by Harvard University. This work holds promise for development of new and highly simplified techniques of programming.

IV. Scope of Application.

Our programmed instruction research is ranging across various traditional training levels: position training, proficiency maintenance, cross training, retraining. It is also ranging across various personnel levels: from operator-technician level, to system commander, to the highest-level managers. The design concept of many of these Information Systems implies that the top-level analysts will personally interact with the equipment. Thus in our work we see a trend towards demands for programmed instruction and automated training techniques suited to highly sophisticated operators. We also see an increasing requirement for adapting programmed instruction techniques to advanced proficiency maintenance training.

In summary programmed instruction research for Information Systems is leading to the following:

I. An advanced technology for implementing programmed instruction.

II. Application of programmed instruction to new subject matters and skills.

III. Development of new programming techniques for these subject matters and skills.

IV. Use of programmed instruction with highly sophisticated learners, and for advanced training as well as for initial learning.

VIII The Health Sciences

PROGRAMMED INSTRUCTION IN MEDICAL EDUCATION

M. S. White, Major General, USAF

General White quotes from a report of the American Association of Medical Colleges which suggest that in order to meet the growing national need for trained physicians, medical schools must change their objectives from the acquisition of knowledge to the selection, organization, and evaluation of new knowledge as a means of continuing post degree education. Programmed instruction is a particularly promising educational innovation that can help both medical students and practicing physicians meet this objective.

As required for all new modalities introduced in education, the first flush of enthusiasm for programmed instruction must be tempered with a careful analysis of its potential value and limitations. A study of the first few exploratory uses of this innovation in the medical field, and a survey of its application in other areas, appear to establish a definite place for programmed instruction in medical education.

The problems facing medical education now and in the future are receiving increasing attenion from not only the medical profession itself, but also from the national government. Various studies of the number of physicians required for the predicted population growth within this country resulted in recommendations for the construction of more medical schools. The need for 10,000 physician graduates per year has been projected compared to the present average of 7,000 who are the product of approximately 85 medical schools. Associated with this demand for physicians is the requirement for additional ancillary supporting personnel required in the health fields.

However paramount the problem of medical education is that concerned with staying current with the increasing scope of knowledge made available through today's rapid technological advances. This applies in the undergraduate field where the limited four years of study presents the difficult task to the embryotic physician of absorbing all the world's medical knowledge. It applies particularly in the graduate field or lifetime learning period required of all physicians, if they are to provide the patients with the best of preventive and therapeutic care.

In medical school the student must be exposed to a solid fundamental education. This long basic period required for the education of a doctor has received continuous study and challenge. Its further lengthening to absorb the increased knowledge available in all specialties of medicine, would decrease still more the productive years available for a physician to render services. Therefore, as one of the objectives of undergraduate medical education, the American Association of Medical Colleges has enunciated that the student must establish essential habits of continuing self-education which will be used when he is no longer confined within institutional walls. With great research advances producing reams of additional scientific information each day, there is an essential need for a rapid means of making this material available to the practitioner for the good of his patients.

In recognition of this problem, a joint study committee in continuing medical education sponsored by many of the leading medical associations of the country, under the aegis of the American Association of Medical Colleges, recently made a penetrating analysis and proposed a solution. In essence, the solution calls for a nationwide university without walls, that will provide educational opportunities for physicians on an accessible, convenient and individual basis.

The report states: "To accomplish this, education for medicine must move from objectives placing such great emphasis upon the acquisition of information toward objectives more effectively promoting the ability to select, organize, and evaluate information in a way that will stimulate, as well as satisfy curiosity and also foster the kind of critical perception which the judgments of a learned profession will increasingly require. In this shift of objectives the acquisition of information becomes a means to an end as well as an end in itself and the manner of learning as well as what is learned can receive the proper emphasis".

The report then states: "This reassessment of objectives with consequent changes in methods of teaching and learning must occur at all levels of physician education: the medical school, internship, residency, and professional practice".

It is in this context then that we can determine how programmed instruction can be used. Paramount must be kept in mind that a curriculum must be developed that will best meet the end objectives, regardless of the teaching methods used. A teaching medium must not dictate the curriculum. Thus, in many medical areas, instruction cannot take place except through a preceptor closely supervising a student's handling of live patients. In other areas such as the reports of latest medical research, mass teaching can be accomplished through the use of video tapes and instructional television. In areas of basic fundamental teaching and continuing education, it can be seen that programmed learning techniques could be particularly advantageous. Programmed instruction can provide for individual instruction at places and times convenient to both the undergraduate and graduate physician. Programmed instruction can be pursued at a pace commensurate with the student's ability. Programmed instruction can assure a minimum standard of academic performance, an assurance that the knowledge necessary in any particular subject has been attained. As a result, the specter of facing the achievement testing procedures that have been customarily used should not preoccupy the attention of students, when demonstrating their qualifications in basic or advanced studies and specialties.

When used to supplement other educational techniques, the success of programmed instruction will depend on the development of effective programs. The skills of competent programmers must be allied with those of the scientific teacher. Each must be certain that the program has measurable objectives; that student gains are obtained based on criterion tests; that the program can be completed in a reasonable time; that retention of material persists over a realistic time period; that the program is geared to the ability and qualifications of the student; and that the program, before being adopted, was evaluated against alternate methods of instruction with comparative gains demonstrated.

When these criteria are met, it is likely that improved quality and effectiveness of medical training will be accomplished. There can result a more widespread use of highly trained instructors, to meet the burgeoning needs of medical schools. Student time spent in acquiring basic factual knowledge can be reduced. There will also be lessened failures and repeats. Instructors will have more time to deal individually with students, and in laboratory and clinic, stimulate their intellectual curiosity.

In accepting new techniques for imparting education, the zealous advocate may mistakenly feel that he has a new and easier system for presentation of the same material. This delusion must be dismissed, for an all together new approach to education should be attained. It is imperative that full advantage be made of these educational advances, whether programmed instruction, instructional TV or others, by adapting to the new technique rather than a simple transfer of course material into the system. Most medical educational institutions now existent, designed about educational methods which have changed little in the past 50 years, permit little opportunity to start from scratch and adjust their whole approach to instruction with these new methods. Evolutionary transition will be the rule in these instances as physical and other limitations are overcome. However, in the case of new institutions which are presently being planned, it is apparent that the educator can design his whole curricula and plant about the best distillation of all methods as they become proven, for the benefit of both students and instructors. Proper projection studios, classrooms, laboratories, individual study areas, libraries, clinics, operating rooms, consultation rooms, all can be designed for these new techniques at minimum cost compared to the rehabilitation of older institutions. Such a task presents a wonderful and formidable challenge.

At the present time, the use of programmed instruction in medical education has been initiated on a small and experimental scale in some medical schools, in military technical schools for training of para-medical personnel, in pharmaceutical companies for training of sales representatives who deal directly with physicians, and in post-graduate or continuing courses for physicians.

Preliminary evaluation of results has indicated the effectiveness of this form of instruction. At Dartmouth Medical School in Hanover, New Hampshire, Drs. Green, Weiss and Nice are pioneering in research on the applicability of programmed instruction in a medical school. Courses developed to date have been from a research point of view only, in order to evaluate the effectiveness of programmed learning at the graduate level. The courses tested have been parasitology, biochemistry, a review of the autonomic nervous system in relation to the pharmacology course, gross anatomy and neuroanatomy.

From the original experimental course, the investigators have concluded that programmed instruction is an effective technique for teaching a laboratory course such as parasitology. Students achieved a significantly higher test performance in this course compared to their grades following conventional instruction. Also, less study effort was required by the more productive students to reach the same high levels of performance, while the less productive students required less study time and achieved higher scores.

At the University of Illinois College of Medicine, in Chicago, an experimental study is being made with the introduction of courses in body fluid metabolism, biochemistery, physiology and internal medicine. Similarly, experimental programs are being introduced at the Western Reserve School of Medicine in Cleveland in hematology; at Columbia University College of Physicians and Surgeons in New York City in urology; and in the New York Hospital, Cornell Medical School on the thyroid gland.

Opportunities appear legion for the application of this technique throughout other medical courses. Better utilization of a student's study time can be made and he can obtain the background knowledge and freedom to profit from bedside and laboratory discussions with instructors.

Medical courses developed for training of professional sales representatives of drug companies have as their objective the attainment by the representative of a thorough understanding of the medical background, the product background, and the associated terminology necessary to discuss the drugs under consideration intelligently with physicians. Programmed texts for this use have been developed in bacteriology and antibiotics, cortico-steriod pharmacology, glucose metabolism and insulin, female endocrinology, cardiovascular physiology and diuretics, fungus diseases and griseofulvin. These courses vary in study time from one and one-half hours to fifteen hours, with most requiring eight or nine hours.

In continuing education an example of programmed instruction's potential contributions can be seen in the course on allergy and hypersensitivity made available in June, 1963, to all physicians without cost. The course consists of 361 frames and requires three to five hours to complete. The sponsoring company throughout the year, will distribute other short post-graduate courses, prepared by competent programmers working with subject matter specialists from leading medical schools.

Thus, we see the awakening of interests in the potentials of programmed instruction throughout all echelons of medical education.

Preliminary experimental evidence indicates that there is opportunity for the adoption of this method of instruction with other new educational techniques in many segments of medical curricula.

As continued experimental studies are made and future refinements develop, we will eventually see programmed instruction fit into its proper niche for maximum contribution to education in the health professions.

PROGRAMMED INSTRUCTION APPLIED TO SELECTED ASPECTS OF DENTAL EDUCATION

Dale W. Podshadley

Dale Podshadley reports two studies which demonstrate autoinstructional methods can be used to teach basic dental science and public health materials to dental students. Part of the dental science material was revised into narrative form and used effectively as a refresher for practicing dentists. He concludes that wider use of programmed instruction could lead to greater instructor efficiency and curriculum flexibility.

The problems of particular concern in the dental educational process today are not unlike those in the related health professions. At the undergraduate level, the dental profession shares with the other health sciences the task of incorporating the many technological and biological advances into an already crowded curriculum. It seeks, as they do, a curriculum which reflects social as well as scientific progress, and instruction which utilizes to the fullest the findings of educational research. And dentistry, perhaps even more than the other professions, is hampered in its efforts by a shortage of teachers.

Coupled with the difficulties at the undergraduate level is the problem of maintaining knowledge and skills among practitioners. The methods relied on to a great degree such as society meetings, journals, informal contacts, are limited in effectiveness and might be considered haphazard educational experiences. Refresher courses given by the universities probably are the best means currently available. But a busy practitioner has little free time and may hesitate to spend this time and the necessary money for courses which may be applicable only to a small part of his practice. In addition, there are too few schools offering refresher training and these schools are often inaccessible to the practitioners who are least able to stay abreast of new developments by other means.

With this latter problem in mind, we decided on an exploratory study of programmed instruction as a means of facilitating refresher education. If a substantial portion of postgraduate materials were amenable to programming, we could make a significant contribution to improving the continuing education process of dentists.

Our first project was contracted to Stanford Research Institute in cooperation with the School of Dentistry of the College of Physicians and Surgeons of San Francisco. The essence of the study was to determine the feasibility of self-instructional procedures in refresher courses by estimating the effects, measured in learner performance and attitudes and costs, in time, effort, and dollars.

Ultimately a branching program, in book form, was developed on the periodontal membrane, a segment of oral histology basic to refresher courses in periodontics, a specialty of dentistry concerned with the supportive structures of the teeth. The subject area permitted the use of first-year dental students as test groups prior to modification of the material for evaluation with practicing dentists.

In designing the study, an attempt was made to compare programmed instruction with two other forms, a seminar and a programmed lecture. The latter was prepared and delivered by a faculty member who had taken an active part in advising on the construction of the program and the criterion test. The intention was that the lecture duplicate the programmed text. The results of this trial indicated that the self-instructional materials were as effective in teaching the subject matter as the programmed lecture and somewhat more effective than the seminar. However, the seminar group was not exposed to the precise teaching objectives. There was no indication that individual differences between students with respect to their scores on an intelligence test or to their grade-point averages in previous courses affected test scores to any degree. The major place where differences were noted was in the time required to complete the program, from thirty to ninety minutes.

On completion of this phase of the study, the material was refined for use with practicing dentists and an additional program (on the cementum) was prepared. Again to provide some comparison of the programs with conventional methods of instruction, narrative versions of the programs were written. These narratives were identical to the program with the exception that the correct answers to the questions were phrased as statements and the questions were omitted.

A major finding in a comparison of the two methods with matched groups of dentists was that the programmed materials and narratives were equally effective, with the narratives requiring less time for completion. An assumption is that the narrative was sufficient to reinforce previous learning since all the participants had been exposed to the material at some time in their professional careers. Of course, an unanswered question is whether a narrative of equal effectiveness could have been prepared without the process of programming.

The readers of both the programs and the narratives thought the materials compared favorably with conventional textbooks although neither method was thought to be superior to a lecture. Of concern, in this regard, is the problem of programming material adaptable to individuals with various levels of knowledge in the subject matter. In this instance, some of the participants probably were bored by content which they either knew or recalled rapidly. The importance, with conventional programming methods, of developing a program for a specific group with similar knowledge or no knowledge in the subject cannot be over-emphasized. However, whether a comparison of materials new to the participants would have resulted in different reactions is unknown.

With the project in oral histology underway, we decided to try programming an entirely different subject, that of dental public health, which is tied more closely with philosophy and attitudes than with facts. Our primary interest was in methods which would conserve the time of the instructor, allow flexibility in relation to the students' time and, in particular, assure that a student had been subjected to a pre-determined body of public health content.

This program, also in a branching format and prepared by an experienced programmer, requires from one and a half to three hours for completion. Evaluation of the unit, entitled, *Introduction to Dental Public Health,* has taken place in five schools, using either a "scrambled book" or a multiple-choice microfilm device. Although analyses of the data are not complete, there is no doubt but that the program is effective. The reaction of the students, both dental and dental hygiene, has been more favorable than expected, with ninety per cent indicating a preference for additional programmed instruction. In addition, by far the majority of students consider the programmed material to be more effective than either conventional textbooks or lectures.

On the basis of our experience, much of the lecture material in dental education (and undoubtedly this applies to the related professions), could be effectively and efficiently taught by self-instructional methods. The fundamentals in the basic sciences, where the laboratory sessions could be designed for reinforcement, seem particularly amenable. Similarly, the fundamentals in the clinical sciences and many parts of the subjects relegated to the clinical years could be programmed. Perhaps the lecture time saved would provide the curriculum flexibility needed and the efficiency of instruction would permit the addition of new courses or the expansion of existing ones.

The surface has barely been touched in exploring the potential of programmed instruction, particularly the value of automated or machine-controlled teaching. Self-instructional procedures have a place in dental education now and will have a greater place as more efficient methods are developed. We are using the conventional methods in developing additional materials, but we also are planning more intensive studies, particularly in relation to new methods.

The experience of programming is invaluable if never carried beyond the development of precise instructional objectives. Perhaps this is where the major benefit ultimately will occur.

PROGRAMMED INSTRUCTION IN NURSING EDUCATION

Evelyn Revels

Evelyn Revels is active in the evaluation of nursing curricula for the state of Texas. She surveyed a nationwide sample of nurse educators to gather information on their interest in, and use of, programmed instruction. Her respondents expressed a desire for programs in a wide variety of subjects. But because of lack of knowledge or available material, relatively few of them are currently using programmed instruction.

Nursing, in common with many professions, suffers from a great shortage of both teachers and practitioners. My own limited experience with programming has convinced me of its usefulness, and of its vast possibilities as an effective aid in teaching some parts of nursing courses. I believe that it is vital to the future of nursing education that programmed instruction be developed to the most effective extent possible, and as soon as possible.

However, before recommending nursing courses, or parts of courses, for programming, I felt it necessary to obtain specific information from the facilities of a nation-wide sampling of schools of nursing, so as to ascertain what is now being done in programmed instruction, and also, what courses might profitably be programmed, in the opinion of nurse educators.

Questionnaires were sent to 112 of the 1,084 schools of nursing in the nation, or one-tenth of the total. Questionnaires were sent to every state except Alaska, which has no school of nursing, and to the District of Columbia and Puerto Rico. Every type of nursing curriculum was represented in the survey.

About four-fifths, or 90 of the questionnaires were sent to the college-controlled programs, baccalaureate and associated degree granting institutions, the other one-fifth of the questionnaires were sent to diploma schools of nursing. The reason for the heavy weighting in favor of the colleges is that on a national basis the collegiate instructors are reputed to be the leaders in developing new and more effective methods of teaching. Of course, many diploma schools are very progressive in their methods of teaching. In addition, these schools continue to educate the majority of the nation's nurses; therefore, it seemed desirable to obtain a sampling from these schools, as well.

The response was excellent to the questionnaire, with 85 (77%) of the questionnaires returned. Only five respondents (6%) were using any kind of programmed materials, and of the 80 (94%) not using programmed instruction, 25 (31%) stated that no appropriate material is available in nursing. Twenty-eight respondents (34%) indicated that they are either not informed about programmed instruction, or that their knowledge is limited. Eleven (14%) said that they are preparing their own material, or are planning to prepare their own, but do not yet have it ready. Instructors in six schools (7%) are studying programmed instruction and the materials available. Only three respondents (4%) questioned the value of the material available, and two respondents (2%) questioned the cost.

Many of the respondents indicated that they would like to use programmed material for all of the courses listed. A breakdown of their preference is as follows:

Dosage and solutions	70%
Medical vocabulary	55%
Pharmacology	53%
Signs, symptoms & pathology of clinical nursing courses	47%
Anatomy and Physiology	37%

In addition, faculty members listed the following courses as being appropriate for programming, and stated that they would like to have these courses programmed: Skills in Nursing; History of Nursing; Chemistry; Communications Skills; Asepsis in Operating Room; Legal Aspects of Nursing; Microbiology; Communicable Disease Nursing (part of course); Descriptive Psychiatry; Nutrition; Leadership Skills (part of course in unit management).

Of the five respondents who are using programmed material, three schools prepared the material themselves for the following courses: (1) operating room nursing (part of the course), (2) maternal and child health nursing (part of the course), and (3) Anatomy and physiology and Medical-surgical nursing (parts of both courses).

The other two respondents who are using programmed instruction materials have courses published by a commercial group. The courses are "Teaching the Diabetic Self-Care", and "Asepsis Techniques".

Of the five schools using programmed instruction materials three appraised them as very valuable, one as valuable, and the other school said they are unable to evaluate the materials yet, since they have just started using them.

Based on the evidence gained in this survey, very little has been done, or is being done at present in developing programmed instruction materials for nursing education, but a great deal of interest and enthusiasm concerning this field was expressed by nursing faculty members.

In the light of information gained from this nationwide sampling, the following recommendations would seem in order: (1) that nurse faculty members review programmed materials now in existence to determine possible use in nursing education, (2) that individual nurse faculty members analyze courses they teach to identify parts which might be more effectively presented through programming and that they try programming some parts of their own courses. The process of programming a course forces the teacher to think more deeply about her course material, and she is a better instructor for it, and (3) that, where possible, persons trained in programming be used on a full-time basis to develop the programmed instruction materials that would be of value in nursing. These persons would need to work closely with nurses who are subject-matter specialists.

The teacher using programmed instruction would be free to devote more time to the truly creative part of her teaching duties; that of teaching nursing students, by precept and example, how to apply the necessary scientific facts and principles in such a way as to give tender, compassionate care, filled with human understanding, to the suffering sick under their care.

IX Instructional Programming

INCREASING THE PRODUCTIVITY OF PROGRAMMERS

Albert E. Hickey

Albert Hickey emphasizes the point that programming is still primarily an intuitive art and as such is inefficient and expensive. The author suggests concentration on development of better methods of selecting programmers, and on the development of algorithmic or recipe-like strategies for programmers. He also suggests the development of a rigorous and specific language structure for adequate application of the algorithmic programming system.

As Donald Cook has observed recently, Watson, forty years ago, outlined the philosophy of behaviorism. Then, ten years ago, Skinner brought behaviorism to bear on education through the example of his teaching machine. Skinner's teaching machine is important in this sequence, not only because it closed a gap between experimental psychology and education, but because it showed how autoinstruction could reverse the trend toward mass instruction by restoring the one-to-one relationship between student and teacher. If anyone doubts the social significance of autoinstruction, he need only consider that, since Skinner proposed his machine ten short years ago, elementary and high school enrollment has increased by 50% and college enrollment has nearly doubled.

We are agreed then that we must proceed as quickly as possible to exploit the full potential of autoinstruction. Many people, more or less interested in education and training, are rushing to fill a vacuum. But it is not a vacuum that will be filled by mere numbers. In the ten years that have elapsed since the introduction of the Skinner machine, we have not grown very much in our understanding of programming for autoinstruction, not nearly enough to make effective use of all the would-be programmers.

This observation on the state of the art in programming should not be misconstrued as a statement that good programs do not exist, or that all the programs to be published will not be good ones. It is true, however, that all programs are being developed intuitively and then tested, a trial-and-error process that is much too inefficient to meet the great demand for programmed materials.

The efficiency of programming affects all of us in programmed instruction, For example, as a developer and publisher of programmed materials, I cannot safely expand my company without an increase in the productivity of programmers. The efficiency of the autoinstruction industry is also of concern to those of you who are here because you envision educational programming as a career. In the present circumstances many of you will experience frustration and disillusionment. The industry doesn't know how to reliably select programmers, except by a protracted trial and error method that often leads to frustration on both sides. And once we select you, for better or worse, we don't know how to instruct you so that we can be assured of a first class product with a reasonable expenditure of time and money. Finally, those of you who are here as potential users of programs will not be able to afford programs developed intuitively by only a few gifted programmers.

But programmed instruction can't remain a cottage industry forever. What will be done to increase its productivity? There are at least three things I expect to happen.

1. Sharpen our ability to select programmers.
2. Improve our ability to give programmers frame-by-frame guidance through the development of some basic algorithmic models, and
3. Develop an algorithmic or procedure-oriented language to aid in the analysis of the educational process and assist in communication between members of the programming team.

First, in regard to selection, with the assistance of the Liberty Mutual Insurance Company, one of our clients, our company is seeking to establish norms for programmers on such standard selection devices as the Kuder Preference Test and the Thurstone Test of Mental Alertness. These data will accumulate very slowly, however, even in a business the size of an insurance company. I would suggest that the National Society or the Air Force, which seem to be largely congruent here in San Antonio, could help a great deal in this effort since they each, or both, represent the largest sample of programmers whose work can be judged. Of course, judging these programmed materials will be a problem itself. Lewis Eigen, executive vice president of the Center for Programmed Instruction, recently admitted that after writing and reading hundreds of thousands of frames he couldn't tell a good one from a bad one. Fortunately, I think he was overstating his case.

A second requirement is for algorithms that are more detailed, explicit and testable than the gentle admonitions we now follow called RULEG, EGRULE, and "guided discovery". Please don't misunderstand me, these are important formalisms, but they do not yet contribute to productivity.

Perhaps it would not be out of place to explain what we mean by an algorithm in learning. The range of learned behavior extends from, say, the eyeblink at one end of a continuum to problem solving and conceptually mediated behavior at the other. Let us concentrate on the more sophisticated end. Problem solving and conceptual behavior are not mutually exclusive. To establish a concept it is often desirable to perform the operations that define the concept and in many cases the operations to be performed to solve a problem. Thus the teacher or programmer leads the student through a sequence of operations or responses. The operations are performed in a linear sequence because the student can perform, or at least attend to, only one operation at a time. This does not, of course, preclude branching at criterion points.

What is the best sequence of operations for teaching a given concept? Unfortunately, no books tells you how to proceed from the point where you agree on terminal behavior to a frame-by-frame plan. Bruner observes that students left to their own devices show little agreement on strategy. Further, observation of teachers' classroom behavior and the analysis of textbooks suggest that teachers, as lecturers and authors, do not follow a consistent sequence of operations in concept formation. Teachers of economics, for example, disagree markedly on an optional teaching strategy. Approximately 60 per cent of the teachers follow a micro-macro sequence, while the other 40 per cent sail the opposite course.

At present the concept formation strategies used in programmed instruction sequences, like those in textbooks, are being intuitively contrived. The claim that programmed sequences are "logically structured" refers at best to a very informal and personal logic. The current "logic" is not the logic of formal analysis. As I say, the closest approach to a formalism is the RULEG principle of Evans, Glaser, and Homme. Gagne and Brown have suggested a deductive or inductive sequence called "guided discovery". Myron Woolman has proposed the use of a programming lattice.

All these recommendations are, however, too general. We continue to rely upon programming artists to plan concept formation strategies. Many programming activities have organized programmers in teams around individuals with a teacher's insight or instinct. But this is an inadequate step at best. The key man himself would be more valuable, and his communication with other programmers improved, if he could talk more rationally about concept formation strategies.

There is at least one ray of hope in this cloudy picture. That is that there is reliable connection between the logical structure of a subject matter and the most efficient concept formation sequence. Let me speculate on what that relationship might be.

Programmed instruction sequences for concept formation build toward a "terminal frame", which is usually a verbal or graphic definition of the concept. The definition is a collection of the properties or qualities of the concept and their relationships.

For example, the concept of a triangle is comprised of two properties: threeness and polygonism. But polygonism is only the specification of more general properties. A polygon is a plane. A plane is a magnitude. A magnitude is a quantity. Therefore, a triangle is a quantity. This chain is called a Goclenian sorite. It progresses from the more to the less abstract. In the case of the triangle, we have two sorites, one for numerosity and one for polygonal, which converge on the definition of the concept "triangle".

The definition of a more complex concept, for example the consumption function in economics, represents the convergence of at least two properties, income and consumption spending, each of which is itself a complex concept. Consumption spending is the convergence of consumer and spending, and spending is the convergence of exchange, and goods and services. This hierarchy of concepts can be illustrated with a "tree" diagram, and a rather bushy tree at that.

Since instruction is a "single-thread" process, the complex n-dimensional concept must somehow be reorganized into a linear verbal learning sequence or algorithm. In this transformation, which property of concept triangle should be introduced first in the learning sequence for concept triangle, "3-ness" or "polygonal"? The artful programmer might at first say "it doesn't matter". Later he will usually feel he should take up one property before the other. For example, some properties or subconcepts have more involved derivations than others. This may lead to their earlier (or later) treatment in the linear program. To generate an experiment, I would venture this hypothesis:

> **The most efficient learning sequence is the one in which each succeeding element is a more general case of the preceding more specific conceptual elment.**

So much for algorithms. The third requirement is to develop a more efficient language with which to deal with these problems of program organization. English is too unwieldy. We can expect therefore to evolve a special algorithmic language similar in certain ways to the algorithmic language used to give instructions to computers. After all, students learning to solve problems share a common characteristic with computers: they both respond to step-by-step instructions. A major differences between computers and students is that computers function solely to give solutions, while students solve problems not just to get answers, but to learn how to solve other related problems.

To give step-by-step instructions to their problem-solving computers, mathematicians began some time ago to devise special languages such as ALGOL, COBOL, FORTRAN, LISP, and JOVIAL. These languages range from hardware oriented languages suited to specific computers, to meta-languages with a great deal of generality. Since educational programmers are not yet constrained by machines, they should be able to develop an educational language of some generality. Now you can't make any progress in research unless you have an acronym that sounds like a name, or a name that sounds like an acronym, so let's call our new educational language DIDAC. Like other algorithmic languages, DIDAC will have a number of symbols standing for relational operators, logical operators, sequential operators, arithmetic operators, and declarators. The symbols will be composed into statements, labels, blocks, procedures, and programs. DIDAC will have a number of extra symbols, however, since the human brain can perform more sophisticated operations than an electronic computer. The most difficult task will be to specify the syntax, the rules governing the combination of symbols for most efficient learning. The sequences will probably not be the same sequences used just to get quick answers. The inventors of DIDAC will suffer a handicap not shared by the originators of computer languages. Psychologists have only a very poor understanding of the operations which result in human learning, while engineers have always been able to tell computer programmers how electronic computers function. After all, they invented them.

Unlike instructions to computers, which are carried out entirely by the machine, instructions in DIDAC will be carried out partly by the teaching machine and partly by the student himself. In fact, present programmed instructions look a lot like the script for a dialogue between a teacher and a student. Students will not need to know DIDAC, however. It will be used only to program the actions of teaching machines. The output of the machine will be plain language, or graphs and pictures. Classroom teachers probably will not find it necessary to learn DIDAC either, at least for the present. The language will be used only by educational programmers. And nothing should enhance the status of programming as a profession more than a private language.

In summary, programming is presently a craft industry, but the tremendous demand for autoinstruction calls for greater production. To achieve this we need better criteria for the selection of programmers, more detailed programming algorithms, and an algorithmic language for educational programming.

USEFUL OBJECTIVES

Jerry Short

Jerry Short reminds us that a programmer can get positive reinforcement for talking about behavioral objectives, but to date there does not appear to be a contingency that will reinforce people for actually publishing them. More importantly, there does not appear to be a technology for developing frames from even a well developed objective. Dr. Short suggests a method for bridging the gap. He also suggests a partial format for a manual to accompany any programmed materials. His format should give a reinforcing market advantage to the programmer who actually follows it and publishes the behavioral objectives.

One of the primary targets of the revolution called programmed instruction was the moldy Bastille of educational objectives. Inside this prison under the old regime, courses were described in vague terms. Students were expected to understand, appreciate, and know things, and what this understanding, appreciation, and knowledge looked like was seldom considered and never elaborated.

Since programming came directly from experimental laboratories concerned with the behavior of organisms, it is not surprising that its advocates viewed education as a process of behaviorial change. A program was not designed to convey information. It was designed to produce a change in the behavior of the student. Its objectives were not to impart knowledge, but to alter the student's response to his environment. Thus, it was argued, objectives of programmed instruction could best be described in terms of the stimulating environment and the student's behavior in its presence.

This concept is summarized in Robert Mager's "Preparing Objectives for Programmed Instruction" (Mager, 1961). In that book, the right answer is the action word which describes what the student does, not what he knows; how he behaves, not what he understands. Dr. Mager's recommendations to describe educational objectives in terms of stimulating environments, modifying conditions, student's responses, and criteria of acceptable achievement have been widely adopted in training programmers. And this is as it should be, for no characteristic of programmed instruction is more important than the concept of education as a process of behavioral change. The concept that educational objectives should be stated in terms of (1) stimulus conditions that can be replicated and (2) observable responses that have a high probability of occurring in the presence of these stimuli is relevant.

Everyone appears to agree that behavioral objectives have joined the select company of "motherhood" and "country". They are good things in and of themselves. They must be determined before a frame is put on paper. They must be published so that programs can be evaluated. They must be reported in research studies so that other experimenters can judge and replicate the studies. But, if such objectives exist, they are well guarded secrets. I have looked in vain through published programs, manuals, and reports to find detailed objectives describing the behavior change that is to occur as a function of the student's taking the program. I smile every time I see that someone else has suggested that a teacher or supervisor should choose a program by "comparing his course objectives with the program's objectives". I can only think of the poor teacher or curriculum supervisor comparing two blank pages, one *not* listing his own educational objectives in behavioral terms and the other *not* listing the program's.

Programmers, myself included, frequently talk about objectives, but often neglect them when writing a program. One reason for this neglect is the lack of aversive stimuli whose removal might reinforce writing objectives. This is in contrast to the aversive stimulus of a deadline that keeps many programmers writing frames: the Sergeant must produce frames so that the Lieutenant can show the work to his Captain who can demonstrate to a Major that he and his staff should continue to exist. The same aversive control exists in the chain of command from a programmer to his company's publisher. But the emphasis is always on publishable frames, never on the publishable objectives. In addition, frame writing behavior is often controlled not only by the withdrawal of aversive stimuli, but also by positive reinforcement from supervisors: "Ah, you've produced 50 frames this week. Good! Here's an extra package of frame paper." In contrast, the behavior of writing objectives is seldom followed by anything resembling reinforcement. In fact, punishment may well be the usual environmental event that follows the presentation of a well formed objective to an uninformed supervisor.

It can also be argued that little would be gained at the present time from publishing objectives even if programmers were reinforced for producing them. The behavioral objectives of programmers may sound limited and meager in comparison to the claims of other educational marketers. The very precision that means so much to the programmer may indicate a limited coverage to the curriculum supervisor. Because a mathematics program does not claim to teach understanding of addition, appreciation of subtraction, and a love of number concepts, it may seem a bad buy. The idea that the claims of educational techniques should be substantiated is new. A few years ago, no one had seriously thought of returning textbooks or films to their manufacturers because 10% of the class using them made F's and obviously did not learn to love number concepts or appreciate subtraction. The precision of program objectives is impressive only when the objectives are paired with student data illustrating achievement of the objectives. Until such data are available, behavioral objectives will sound somewhat limited when compared to the advertised objectives of other techniques.

Apparently the writing of behavioral objectives is not often reinforced by money, publication, praise, or other secondary reinforcers. Nor is it necessarily reinforced by effective frames and programs. Although much has been said about preparing objectives, a large void still exists between this step and writing a program. There is usually a missing chapter in books on programming because no one has yet described exactly how a behavioral objective can be converted to a program sequence. And many programmers, even after devoting considerable time to specifying what they plan to teach, have difficulty determining how they will teach it. Therefore writing objectives in behavioral terms is often not even rewarded by the rapid development of an effective program.

Before I change from critic to advocate and before I suggest how writing objectives can be made rewarding, I must specify two crucial elements of a behavioral objective. For unless the objective specifies both a stimulus and a response, all my recommendations are useless.

Table 1 lists three objectives that we will assume refer to the same behavior pattern. The first objective can be criticized because it does not tell the instructor what to teach or how he can observe if his teaching is successful. It is an unreliable objective because different teachers or programmers would teach different things and, if they observed achievement at all, would certainly measure it differently.

Table 1

A. The student will understand the nature of classified materials.

B. The student will define classified materials.

C. The student will define classified materials as documents that, if seen by unauthorized personnel, could damage the security of the United States.

The first objective in Table 1 cannot be made more useful by substituting an "action" word for the word "understand." Thus Objective B "The student will define classified materials," is little better than Objective A. We may have reduced the variance in teacher behavior by substituting the word "define" for the word "understand," but different teachers would still teach different things and measure success in different ways.

We can improve the objective by describing the response in more detail. Objective C in Table 1 seems behaviorally stated. However, it does not specify a stimulus. It does not tell what environmental situations will start the student defining. It might be argued that Objective C implies a stimulus such as the question "What is classified material?" But this may not be the stimulus that the programmer actually uses. His frames may indicate that he is using the definitional phrase as the stimulus and calling for the response "classified." Or he may be interested only in having the student recognize the response phrase and therefore writes multiple choice frames in which "classified material" and the phrase defining it are both stimuli and the student makes a matching response. At least three stimulus-response patterns, all representing the "behavior of defining," could be correctly derived from Objective C. They are listed in Table 2.

Only if an objective is stated in terms of a stimulating environment and an observable response as illustrated in Table 2, will it reliably describe the behavior that is to be taught. And only if it is stated in this way, will it program easily.

I would like to describe one method that I have used to bridge the gap between an objective and the program materials written to achieve the objective. I will only briefly describe it here. You must wait anxiously until later when the method is either abandoned or worked out in detail.

Since the answer the student will make in the program is ideally the response specified by the objective, we begin writing the program sequence by making an educated estimate of the number of times the student will have to make this response or parts of it. If these responses are listed on the back of frame cards, we have some frames that are one-third complete. The program responses are relevant and important because they are are the responses required by the objective. In the program, a frame should not simply evoke a response, but evoke it in the presence of stimuli that will eventually come to control it. Since these are the stimuli listed in the objective, they can be transferred to the other side of the frame cards. Sometimes the exact stimulus listed in the objectives can be used, but often new

Table 2

Objective C: The student will define classified materials as documents that, if seen by unauthorized personnel, could damage the security of the United States.

Stimulus-response patterns suggested by the objective:

	Stimulus	*Response*
1.	Define classified material	Documents that, if seen by unauthorized personnel, could damage the security of the United States.
2.	Documents that, if seen by unauthorized personnel, could damage U.S. security are called	Classified material.
3.	Documents that, if seen by unauthorized personnel, could damage the security of the U.S. are called: a. .... b. .... c. .... d. classified materials	Matches stem to choice d.

examples or generalizations are required. Certain stimuli that should also elicit this response and certain "S" delta conditions (stimuli to which the response should not occur) are also added.

The objective has yielded a number of pieces of paper with desired responses on one side and appropriate stimuli on the other. These are then given to a Subject Matter Expert to see if the stimuli will evoke the desired responses from him. Unless the stimuli are effective enough to evoke this behavior in an expert, there is no reason to expect them to reliably evoke the response in the trainee. The incomplete frames are revised on the basis of the Subject Matter Expert's responses. They are then sequenced and cued to assure that students will make the correct response in the presence of the appropriate stimulus. Each part of the frame is clearly distinguished by its function: the cue is used to assure a correct response, the frame context represents the stimulus pattern that will eventually control the response, and the response is clearly relevant to the objective. In this method, the mechanics of determining responses, establishing stimulus control, and adding effective cues precede the drafting of an item into a program frame. It is a method which promises to reward writing objectives by clearly specifying how a program sequence can be produced from an objective.

My second suggestion for improving the reinforcing contingencies affecting writing objectives depends on the recommendations of evaluation groups such as the Joint Committee on Programmed Instruction and Teaching Machines formed by AERA-APA-DAVI. If the committee recommends a manual for programs that emphasizes the behavioral statement of objectives, then professional approval and, to some extent, sales will be contingent on writing these objectives. A program manual that emphasizes behavioral objectives might take the form shown in Table 3.

Table 3

Suggested format for program manual:

OBJECTIVE 12:

Stimulus	*Response*
When the student is given (1) a political map marked in degrees of latitude and longitude and (2) a question asking him to name the city at—latitude (N or S) and—longitude (E or W)	he will name the correct city

Criterion test items for Objective 12:

Stimulus	*Response*	*% of sample answering item correctly*	
Use map A. Write the name of the cities located at these coordinates. 33° 56′ S, 18° 25′ E.		*Before Program*	*After Program*
30° 3′ N, 31° 21′ E.	Cape Town	4%	95%
	Cairo	2%	98%

Under each objective, the manual lists the criterion test items and the field test data that indicate student achievement of this objective. This three-part description of a program in terms of the behavioral statement of the objective, the criterion test items measuring achievement of the objective, and the student data showing success on the test item, would present a clear picture of what the program was designed to do, what the student was actually asked to do, and how well the program had succeeded.

A Subject Matter Expert might be challenged to publish a book in the form of Table 3 that set forth the objectives of some course in his special field. The book would list all the important behavioral objectives and give examples of what he meant by these objectives, i.e., problems which the student should be able to solve, sentences or essays which he should be able to write, etc., when he completed a course based on these objectives. Such a book would be controversial, in itself a reinforcing event to any Subject Matter Expert. It is difficult to guess how many reviews he would get for publishing a list of objectives for English Literature 1, Philosophy 4, Introductory Chemistry, or even Algebra, Geometry, and First Year Spelling.

In summary, I have tried to examine the paradox between what everyone says to do—write behavioral objectives—and the environmental events that do not reinforce this behavior. I have suggested that a suitable environment might be created (1) by developing objectives which can easily be converted into program sequences and (2) by reporting program evaluation in terms of objectives that specify a stimulus and a response, criterion test items that measure achievement of objectives, and field test data that show actual achievement. These suggestions, it is hoped, should make writing objectives not only necessary and mandatory, but also useful and rewarding.

TASK ANALYSIS—BANE OR BLESSING?

Charles G. Latterner

Charles Latterner discusses task analysis. Task analysis is the determination of what a person does, how he does it, why he does it and the skills involved in doing the work. Although it is a tedious, time consuming, expensive and difficult job, that is all too often sacrificed on the altars of the gods of false economy, task analysis is a necessary basis for preparing programmed instruction materials that can guarantee the return of many dollars in fully trained workers.

When any group of individuals concerned with programmed instruction get together to discuss the problems, the techniques, the new ideas, or what not, the place of task analysis in programming generally comes up. As in all things concerned with programmed instruction, there are varying opinions of the worth of conducting task analyses, and these opinions run from the decidedly positive to the decidedly negative, with all shades of opinion in between. There are those who feel that the effort involved in performing a task analysis is just too much for the benefits received. There are others who feel that a really good program cannot be constructed without a detailed task analysis. In other words, is task analysis a bane or a blessing?

The concept of task analysis is certainly not new to most of us. Industrial Engineers have been studying jobs for years. Some training directors have used these task analyses in the development of training programs in fields that require workers to perform certain types of manual work. In many instances, however, training directors have not been too concerned about making full use of the data available to them, and so they have gone merrily on their way, implementing training programs which usually do not meet the needs of the workers when they are put on the job.

Just what is a task analysis? There are many answers to this question, and the definitions of task (or job) analysis run from the very simple to the very complex. Simply put, task analysis is the determination of what a person does, how he does it, why he does it, and the skills involved in doing the work. Actually, describing task analysis in this way relates the subject to the whole demesne of training. It is, in fact, an important part of an evolving training technology, and there are those who feel that task analysis comes first in the chronological listing of a training technology. Some feel that task analysis is the base on which a training program should be built, regardless of whether that training program is of a conventional type or a programmed instruction text.

Why is it said that task analysis is the base on which a successful program can be built? Simply because unless we know what the person is required to do, how he is to do it, why he does it, and the skills involved in doing the job, we cannot hope to be successful in training him. From a task analysis we can easily establish meaningful objectives; we can correctly delineate the threshold knowledge required in the student; we can accurately determine the behavioral changes we want to effect in the trainee; we can select proper subject matter for programming; we can determine correct sequencing for teaching; we can specify appropriate training or programming techniques, and we can establish real criteria for measurement.

Before taking a closer look at how we can use task analysis in developing programmed instructional materials, we should look a little more deeply into the whole process of performing a task analysis.

We have established that a task analysis involves four elements: the *what,* the *how,* the *why,* and the *skills* involved. In finding out what a worker does, an analyst must consider two types of activity: physical responses and mental responses. Physical responses required of a worker in a job situation include such things as grinding or polishing materials; inserting, soldering, wiring; or performing a multitude of other physical activities. On the other hand, a worker may mentally plan, compute, judge, direct, or otherwise govern the expenditure of his own physical activity, or that of others, by a corresponding exercise of mental effort.

In a job, a person may expend any combination of physical and mental effort required by the job to be performed. In finding out what the worker does, the analyst establishes the complete scope of the job by considering the total universe of responses demanded by the tasks to be performed. All of the physical and mental activities involved in the job as a whole, as well as in the individual steps that constitute the whole job, must be carefully considered.

There is seldom, if ever, a job consisting of only one act, be it physical or mental. Most jobs consist of more than one act, or task, but even one task may involve different physical and mental activities on the part of the worker. It is up to the analyst to discover these tasks and report them in the most direct terms so as to develop a clear, concise, coherent, and complete description of the job.

In order that the trained worker perform his job satisfactorily, it is essential that the various steps be taken in the appropriate sequence on the job. At this point, it is well to note that when training materials are prepared, the sequence of presentation may well shift. It does not necessarily follow that the correct educational sequence is the same as the sequence followed on the job. However, at this point in the preparation of a task analysis, the investigator is not necessarily interested in how the training course will be organized. He is only interested in reporting the job that the worker does so that when a program is prepared all the data will be available in clearly understandable terms.

Having determined what the worker will be expected to do as the result of complying with the demands of the job, the investigator should next turn his attention to how the worker will respond. How the work is done concerns the methods used by the worker in accomplishing the assigned tasks. As in the case of delineating what the worker does, the analyst should consider both the physical and mental responses required.

Physically, the performance of tasks may involve the use of machinery or tools, measuring instruments or devices, other related equipment, the following of routines and procedures, and the movements of the worker himself.

Mental responses to the demands of the job lie chiefly in the "know how" that must be applied to the tasks. This may involve the use of calculation, formulas, the application of judgment, or the making of decisions.

The investigator should assure himself that he has a complete grasp of how the job is done so that when the time comes to prepare the training program nothing will be overlooked or ignored.

Of the four parts of our overly simplified definition of task analysis, perhaps the most important is Why the task or job is performed. Why a worker performs his job is the purpose of the job itself and is indicative of the relationship of the tasks that comprise the total job. In determining why the worker does what he does, the investigator outlines the scope of the job, or stated in another way, he determines the purpose of the job. It is here that the analyst must use the utmost care in ascertaining and recording the reason why each task is performed.

The investigating analyst must do this for two reasons; first to clarify the overall purpose of the job; and second, to show the task relationships as the job progresses to the completion of the work cycle. Failure of the analyst to explain why an activity is undertaken will leave the impression that the job has not been fully reported, and this can result in ambiguity in preparing training materials.

Finally, the analyst must consider the skills involved in the performance of a task or a job. Defining the skills involved consists of a listing and explanation of the basic factors that must be considered. These elements bring out the manual skills, knowledges, abilities, and other characteristics required on the part of a worker, whether that job is manual, craft, professional, clerical or any other type. The recitation of the skills required in successful job performance consists of all the information necessary to discriminate between jobs and to establish the degree of difficulty of any job or task.

Generally, an analyst will concern himself with accurately reporting on certain elements, among which are responsibility, job knowledge, mental application, dexterity, and accuracy required. The skills required in a job have a direct and potent application in the preparation of a training program.

Having had this brief over-view of task analysis, let us proceed to consider the question asked in the title: Task Analysis—Bane or Blessing? At this point, it would be well to consider the following excerpt quotation from "A Technology for Training Design" a Training Evaluation Report published at Lackland Air Force Base in August 1962. The authors of the report were: Dr. M. A. Zaccaria, Mr. W. E. Driskill, and Col. W. D. Ceely, (1962):

> . . . . . Lackland Military Training Center personnel who are directly concerned with training have become sensitive to the need for a different approach to training program development. . . . this sensitivity has led to the development of a training technology based on five principles.
>
> . . . . . The first requirement for effective training is a definition of job or after-training requirements; second, a translation of these job specifications into specific measurable objectives; third, the measurement of the extent that individuals possess the desired behavior and knowledge prior to training; fourth, the development of training which is specifically relevant to achieving the training objectives and which employs the most efficient methods available; and last, the application of a quality control program that insures that instruction meets objectives and graduates effective performers.
>
> . . . . . In determining the job requirements of the job for which a course is to train, a job or task analysis must be conducted. A job or task analysis should determine the behaviors required in the every day job situation. . . .
>
> . . . . . The job analysis should also include specific examples of the kinds of activities for which the course is to train. These activities can serve as the basis for training exercises which assure that training is relevant to the tasks to be performed.

A reading of the above excerpt calls attention to a significant fact, which is that the development of a job or task analysis is the first step in the development of a training program. From this initial effort flow all other training activities.

Perhaps we can answer our questions by asking some questions:

How can we teach unless we know what we are supposed to teach?

How can we describe the terminal behavior we want to effect in our students if we do not clearly know what they are supposed to do?

How can we measure the effectiveness of our programmers unless we develop a standard of judgment based on job requirements?

Those who believe in task analysis as an important part of preparing programmed instruction materials contend that task analysis is a blessing to the programmer, and that without performing a task analysis a really superior program can never be produced.

Of course, in all honesty, it should be pointed out that there are negative aspects to using a task analysis as the basis for a program. First, it is tedious, time consuming, hard work. Much research must be performed for the more complex programs. Literature must be searched, workers must be interviewed and observed, and not just once, but over a period of time. Supervisors must be questioned and re-questioned on just what his workers are doing. (As a side note, there have been times when supervisors who really thought they knew what their subordinates were doing, really didn't know until the facts of life were pointed out by the analyst!) Agreement must be reached among the workers, supervisors, analysts, and programmers as to what the job really requires and how to sequence the material. Sometimes the feelings of the ardent proponents of programmed instruction are deeply hurt when they are made to realize that perhaps certain things can be taught more effectively through other methods than by programmed instruction.

It is generally recognized that the preparation of a programmed text is an expensive matter. It takes time and money to prepare a good program. Add to the initial expense the cost of preparing a complete task analysis and we may face the situation of not being able to afford the program at all. Business management generally looks on any training effort with a jaundiced eye. The comptrollers and cost accountants are only too willing to sacrifice La Belle Training on the altars of the gods of false economy. Yet it should be recognized that the expendiutre of a few more dollars can guarantee the return of many dollars in assuring that workers are trained, fully trained, to do the job they are supposed to do.

In summary we can conclude that:

(1) the preparation of a task analysis is the logical beginning for preparing a programmed text.

(2) the development of a task analysis greatly simplifies the definition of clearly stated, measurable, behavioral objectives.

(3) the work of program designers and programmers is simplified by having a task analysis available.

(4) by knowing exactly what a job requires of a worker, we can establish accurate estimates of desirable threshold knowledge on the part of our student population.

(5) we can establish meaningful, measurable, standard of performance on the job, after training.

(6) program designers can more easily select the best programming technique to produce the desired results in students.

(7) changes in operational sequences or techniques can be quickly identified, and programmed instruction materials can be modified more easily.

(8) there will be no doubt that the program will be designed to meet the exact needs.

All in all, despite certain drawbacks, it seems reasonable to conclude that the development of a task analysis as a basis for preparing programmed instruction materials is indeed a blessing for programmers.

JOB ANALYSIS AND ITS APPLICATION TO TRAINING

Joseph E. Morsh

Joseph E. Morsh discusses the current Air Force method of job analysis, and the traditional uses of job analysis in preparing and revising job descriptions, in identifying training requirements, and in providing data for training standards and curricula. He also discusses some of the more sophisticated uses of job analysis which automatic data processing now makes possible. Finally he points out its indispensibility as the first step in the systematic preparation of programmed instructional materials.

The value of job analysis as an adjunct to training has long been recognized in business, in industry and in government agencies. Job analysis is used to identify and organize job content for writing or revising the job descriptions from which training requirements are inferred. Job analysis supports decisions concerning the extent to which on-the-job training may supplement or replace classroom training. Job analysis, by showing the relationship between jobs, may assist in reducing cross-training time. Job analysis provides information for improving the coverage and designating the subject matter emphasis of proficiency tests used to evaluate the results of experience and training. Analysis of current jobs may be used to throw light on changes in training brought about by new equipment, new tools, and new methods of work. Job analysis provides essential data for the development of training standards or revisions of training curricula. Job analysis is especially important in identifying objectives for programmed instruction.

All of these functions depend upon the availability of an effective method of job analysis. Before going on to discuss the applications, therefore, let us digress briefly to examine a method of job analysis that has been developed by the United States Air Force as the result of an intensive research program during the past four or five years.

This method makes it possible to obtain work activity information quickly and economically—information which is dependable and current. The method makes use of an inventory which consists of a list of work activity statements or tasks which are categorized under major segments of the job, called duties. An attempt is made to select tasks which are about the same size, that is, at the same level of specificity. For practical administrative and analysis considerations, the size of a task is subjectively determined so that some 300 statements or less will cover a whole job. Each task statement is relatively independent of other task statements. A statement begins with an action word. It refers to a job activity, something the incumbent does. Statements describing what the individual knows, understands, has responsibility for, is able to do, or is familiar with, are scrupulously avoided along with trite redundancies such as "when appropriate", "as required", or "in accordance with prescribed procedures" and the like.

When the incumbent completes the inventory, he checks the activities he performs. He also adds tasks which he does but which are not listed. In this way the inventory is kept current. When the instrument is revised, written-in task statements are included and unchecked tasks are deleted. Thus the inventory tends to present a true picture of what takes place on the job. In addition to checking performance or non-performance of a task, the incumbent rates all the tasks he does on one or more rating scales depending upon the purpose of the survey. He may indicate the time he spends on each task, task difficulty or importance, where the task was learned, on the job or in technical school, supervision required, or other information.

Since the Air Force is scattered over much of the world, job inventories are administered by mail. Inventory booklets for a related set of jobs are sent to testing officers who are located on practically all Air Force bases. These officers administer the inventories to groups of airmen incumbents or distribute inventory booklets to officers for self administration. The booklets are then returned to a central office for analysis.

Now let us discuss some of the applications of job analysis to training. As mentioned earlier, job analysis is used to discover job content for preparing job descriptions. From the job descriptions certain training requirements may be inferred. The validity of these inferences is directly related to the information available in the job description. The training program may to a greater or lesser extent be dependent upon the accuracy and comprehensiveness of the descriptions of work performed.

The end result of a survey using the task inventory method is a comprehensive and organized compilation of occupational information in quantified form. Various pertinent data are made available for the development of job descriptions. These data include such items as the proportion of the incumbents who perform each task and the average percentage of time spent on each task by those who perform it. Under present analysis procedures, the job descriptions for each skill level, apprentice, journeyman, supervisor, and superintendent, appear as lists of tasks arranged in order of frequency of performance or proportion of time spent. As might be expected some tasks are unique to supervisors, others are most often performed by apprentices, while some tasks are equally often done by all skill levels.

Job analysis may support decisions concerning on-the-job training. During a survey, incumbents may be asked to indicate whether or not each task was learned on the job or in the class room, or whether more or better training is needed for each task. Such information can be used to guide the training program. Those activities which are best learned on the job can be identified and eliminated from the technical school training program.

A systematic job analysis program, combined with electronic data processing techniques presently available, will serve to identify the tasks which are common to two or more jobs, from which the relationship of the work performed in any one job to the work performed in any other job can be determined. Thus the amount and kind of extra training required in transferring to related jobs can be estimated. With the advent of automation and advances made in electronic computation, the problems of cross-training workers in industry and in government agencies have become acute. When traditional jobs are eliminated or become reduced in importance, the former incumbents must be trained to do other work. The question is, what other work? One answer is that people can be most efficiently cross-trained in a minimum of time to the new job which is most similar to their old job. The Air Force method of job analysis makes it possible to determine which jobs are most alike. Jobs which are being considered for cross-training can be surveyed and, by means of an iterative technique, jobs can be grouped in terms of similarity of content. In another approach, cross-training time can be estimated and then jobs with minimum cross-training times can be identified. As automated personnel assignment procedures are adopted, the Air Force job analysis method by providing a great deal of quantifiable data will provide answers to certain of the problems of cross-training that are associated with these procedures.

The effectiveness of job knowledge tests depends upon the completeness and accuracy of the job information available. Such tests must not only have good psychometric characteristics but must also have an appropriate pattern of content coverage. It is essential also, that the number of test questions designed to measure particular functions are directly proportional to the emphasis of those functions in the job. The development of properly weighted test outlines is therefore a fundamental part of proficiency test construction. The task inventory procedure, by obtaining such data as the number of individuals doing each task, the time required to perform, estimated complexity, and importance of tasks, provides a sound basis for the construction of test outlines, and since the basic data are readily kept current, many of the problems encountered in the construction of proficiency tests with appropriate coverage are thus eliminated.

Job analysis is used to predict changes in training that will follow introduction of new equipment or methods. Here we must distinguish between two kinds of job analysis. The job analysis discussed thus far concerns the behavior of persons who are exerting physical or mental effort. The other kind of job analysis can be done in the absence of incumbents. The job analyzed is work that is required. A manufacturer of new equipment, for example, will specify in minute detail what must be done to operate or to maintain the equipment. Training, then, tends to be geared to the specified work requirements. Later it may be found that there is considerable discrepancy between the "work required" analysis and the job as it is actually done by an incumbent. It may be that some unnecessary training has been given or that training has been inadequate for some aspects of the job. Since no job is probably completely new, information obtained from a careful analysis of current related jobs can be used to check and modify training where new equipment or procedures are involved.

Job analysis provides information which is indispensable in developing training programs and in planning and improving training course curricula. This function of job analysis has long been recognized as a tested principle of management. To train a worker for a job, the duties and tasks which the incumbent will be expected to perform must be discovered. On the basis of these, the skills and behaviors desired and the minimum essentials he must attain in training can be determined. A comprehensive program of job analysis will supply complete field information concerning the nature, scope, and requirements of all jobs for which the schools are training. A continuous flow of information collected in many places from persons actually performing the jobs permits schools to keep their curricula vital and up-to-date. Schools are alerted to changes in the content and complexity of jobs and are enabled to keep abreast of technological innovations which induce changes in duties and tasks. The schools are made aware of variations in skills and knowledges required as well as alterations in the relative importance and time consumed by various aspects of jobs. Schools are thus able to keep courses realistic in terms of actual field job performance and requirements.

Job information obtained from individuals who do the jobs for which the school trains insures that school instruction in job performance will coincide with actual job performance. Graduates arriving on the scene of operations will find that they are properly qualified and that they need little or no additional on-the-job training to become effective in their specialty. Thus the graduates and the supervisors on the job have confidence in the training program and in the technical schools responsible for it. The old attitude that there is "a school-taught way" to do a job and "a real way" is eliminated. The school way guided by effective job analysis becomes the real way.

The application of job analysis as the first step in a methodical approach to programmed instruction should now be obvious. For without job analysis there is no systematic way to determine what elements of subject matter or behavioral skills should be programmed. Finally, job analysis is essential in order to obtain criteria for revising and up-dating the entire instructional program.

DEVELOPMENT OF MEASUREMENT DEVICES FOR PROGRAMMED INSTRUCTION

Robert M. Opdycke, Captain, USAF

Robert Opdycke discusses the use of tests before, during, and after the development of autoinstructional programs. He points out that proper use of tests will aid the programmer in identifying the skill level of the student prior to taking the program, help in the evaluation of the program through the development stage, and prove the program in comparison with other media of instruction. Problems encountered in testing programs are also discussed.

It appears that testing can play a more important role in programmed instruction than has heretofore been recognized. This paper suggests some testing procedures that could be used by programmers and program users before, during and after the development of an autoinstructional program.

PRE-ENTRY TESTING

A pre-entry test, as the name implies, is a questionnaire or test given prior to entry into a course of instruction, or in this case, prior to taking a program. This test should be developed after a task analysis has been made and before writing the objectives. The task analysis will furnish the programmer with information on the final product (what must he know and what must he do). The pre-entry test should be designed to furnish information on the repertoire of a beginning student in comparison with the student who completes the instruction.

As a result of a well constructed pre-entry test or questionnaire, the programmer should be furnished with feedback information which will enable him to identify the repertoire of the median of the entry target student population. Proper utilization of pre-entry test feedback data should aid the programmer by eliminating much of the over-programming or under-programming problems which all programmers find frustrating and difficult to prevent.

The pre-entry test should be constructed with items ranging from simple to very difficult with a span that will enable the programmer to objectively identify the knowledge/skill level of the average student. This test may prove to be a differentiating device; this is desired, because the students in the center of the curve of distribution will furnish the programmer with feedback on where to set the level of the objectives for the program.

This concept of pre-entry testing can be illustrated by a formula. "M" is the repertoire of an accomplished master or subject matter expert and "I" the initial repertoire of the entry student. The formula will then be:

$$M - I = D$$

where "D" is the difference between the novice and the master or "D" would be the behavior that must be changed or modified to reach mastery. Since no instruction or behavior change has taken place, then "D" becomes the training differential or training objective.

A task analysis will give a programmer the value of "M." A pre-entry test will give the value of "I," therefore $M - I = D$, the training task or objectives of the program. With minor revisions the pre-entry test could serve as a pre-test for measuring the degree of learning and amount of behavior change when compared to a separate criterion post-test.

Another useful benefit of the pre-entry test after the program is fully developed would be to employ the pre-entry test as a gate or branching device to place students at different stages in the program. A student who scores very low on certain questions in the pre-entry test should be given a remedial program or training to bring him up to the level of the objectives of the program (up to the level of "I," the average initial repertoire). Conversely, a student who excels on certain items of the pre-entry test demonstrates prior knowledge and could bypass portions of the program.

Many techniques are now in use to bypass, wash-back, or take students through a remedial loop in a program. These techniques are an internal part of the program. The pre-entry concept would be external; that is, removed from the program.

The pre-entry test concept is largely hypothetical. Experimentation is needed on pre-testing techniques to develop a test that would take each student to his proper place in a program.

DEVELOPMENTAL TESTING

Developmental testing, debugging and revising are the keys to producing a good program which meets its objectives. Developmental testing of a program as visioned by the author violates most of the conventional concepts of measurement and evaluation. To list a few:

1. A program teaches the criterion test.

2. A program should skew a distribution curve as far right as possible on a criterion test, even to the extent that students make perfect test papers.

3. A developmental test should be so comprehensive and saturated that more time will be spent testing than teaching.

These three comments represent some of the concepts of developmental testing of a program. The philosophy of developmental testing is completely different than conventional testing. A developmental test does not test the student; it tests the program. A studen should not and cannot make errors, only the program can be blamed for errors. If the student fails, then the burden of responsibility rests on the program, never on the student. This philosophy is hard to accept, but is critically important; a developmental test must test the program and never the student.

If the following outlines and procedures were used in preparing a developmental or criterion test, two valuable tools should evolve: (1) a reduction in time to write a program, and (2) a sure knowledge of when a program has reached the criterion stipulated in the objectives.

After the objectives have been written and before writing a single frame or lesson, a programmer should write and develop an extensive, comprehensive criterion test based on the criterion measurement contained in the objectives. Each and every objective and subobjective should have one or more test items related to the terminal behavior set forth in the objectives.

Here are some sample objectives and the related test items:

1. *Objective:* The student will be able to define work, power, and energy.

Test Item: Define work, power, and energy.

2. *Objective:* The student will be able to weigh a given object on an analytical balance within .001 grams.

Test Item: Weigh the sample object on the table at the front of the class and write down the weight.

3. *Objective:* The student will be able to disassemble, clean, and reassemble the carburetor on a 1963 Ford.

Test Item: Using the tools provided, disassemble, clean, and reassemble the carburetor on the car. (Evaluation would be based on how well the car ran after the carburetor had been cleaned and replaced.)

To reiterate, write the criterion test immediately after writing the objectives. The criterion test should test thoroughly each and every objective within the boundaries and terms stated in the objective.

At this stage in program development the objectives are defined and a difficult, saturated, comprehensive criterion test developed. Before starting on the program the programmer and training manager should determine the absolute grade, score, or level of performance on the criterion test that the training manager accepts as minimum passing or minimum for qualifying.

The training manager has the prerogative of accepting the objectives and criterion test as written, adding, deleting or modifying to suit the training needs or requirements as he sees them. Once this effort has a stamp of approval there is little that can be done until the program is completed. Programmers should make this point very clear to management.

The objectives having been written, a criterion test developed and the training manager having accepted the efforts and set a level of achievement, the programmer can now write the program.

After developing a rough draft, the program should be given to one student and this student should be used to clean up semantical errors, grammar, punctuation, cueing, and the like. The individual student will serve the purpose of reducing frame error rate and very little else. After the first student has completed the program, he should take the criterion test; don't grade or evaluate the test but set it aside. Give the program to another student and again perfect individual frames or sequences. The second student should take the criterion test and these results also should be set aside. After approximately five students have completed the program, the frame error rate should be decreasing and frame sequencing should be fairly consistent.

The programmer now has five criterion tests and a small sample of the student population. He should then score and analyze the criterion tests identifying the areas where the students missed criterion test items and the corresponding objectives. This small amount of feedback information should be used to rewrite and correct weak areas in the program. The assumption can be made that if small samples of students missed a certain area on the criterion test then the program did not teach this objective effectively.

Next the program should be revised using the feedback from the five individual students and a new draft prepared. Revisions and testing, using small samples of students, should be made until the program is developed to the degree that it is teaching to the level agreed upon by the programmer and training manager. When the program produces results with small student samples, 25 to 50 drafts of the program should be produced. With feedback results from 25 to 50 students, the programmer should be able to fill any small gaps that were missed by the smaller sample student groups. When a program is producing results with 25 to 50 students at a time, the program should be fully developed and ready for publication as a first edition.

Once the program has been fully developed, the criterion test can be disposed of and a shorter sampling test that is objective and easy to grade substituted to assure that students are completing the program and, if necessary, to identify students who are not performing up to standard.

To reiterate, the two-fold purpose of the developmental criterion test is to first enable the programmer to develop a program by using feedback information from the test to fill any gaps that appear in the program and second, to recognize when the program is producing the criterion standards set in the objectives by the training manager.

COMPARATIVE TESTING

Comparative testing is the comparison of programmed instruction versus other media of instruction. The end-product of comparative testing is statistical data that will prove one method superior to the other. Why compare? Psychologists have made comparison studies too numerous to mention; the evidence supports programming in a vast majority of these pilot experiments; furthermore, when a program undergoes development to produce a controlled and predictable behavior change that is tried and validated by statistics on the criterion test, then why is a comparison study necessary? Unfortunately, programmers will face some managers and supervisors who regard programming as a fad and who insist on comparative statistics.

Comparative testing and comparative statistics are so flexible that concrete procedures cannot be set for any given situation. Here are a few guidelines that can be followed.

The criterion test that is used during the developmental testing of the program can be used as the comparative test if the objectives of conventional instruction are the same as the objectives of the program. If there are differences between the two, then a separate test should be developed containing items that pertain to both methods of instruction. A programmer should be equipped to furnish answers and data to management along the following lines:

1. Method and supporting data to assure that there is no significant difference between student groups before instruction.
2. Comparison of test scores.
3. Retention test comparison.
4. Time comparison.
5. Student preference.
6. Findings and recommendations.

If a good criterion test is used to develop the program, there is no reason why programmed instruction should not prove superior in all of the above points. Programmed instruction is the only educational technology that can safely say that it is developed to completely control the learning situation and is geared to each individual student. At some point in the not too distant future, programmed instruction should also be able to guarantee every student an "A" and also furnish knowledge and skills that are far above our present educational methods.

QUALITY CONTROL PROBLEMS AND THE SELECTION OF WELL-CONSTRUCTED PROGRAMS

Shirley B. Bitterlich

A step-by-step procedure for developing programs of high quality, from detailed preliminary planning to testing and revising, is presented by Shirley Bitterlich. Practical suggestions for judging programs by the prospective user are included.

The goal of every programming company is to produce a program of high quality. If the effort is successful, the result is a deceptively simple piece of work: simple, because it flows smoothly and teaches easily and well; deceptive, because it reflects in no way, except in its apparent simplicity, the problems which have been faced during its construction. This paper will discuss some of the problems which arise during the preconstruction and construction phases of a program, and also some of the criteria which may be used to judge the degree of excellence of a program.

Detailed preliminary planning is essential. The subject-matter area must be thoroughly researched. In the writing of an academic program, curriculum surveys are made, textbooks are reviewed, current research in the topic area is studied, and a subject-matter specialist consulted during all stages of planning and production. Only after the subject area has been thoroughly explored can the topic outline be drawn up, analyzed, and broken down into the specific objectives.

Preliminary planning serves a three-fold purpose: to validate the subject-matter content, to ensure that all necessary behavioral objectives are taught, and to guide the construction of a properly sequenced program.

The preconstruction phase entails careful consideration of many diverse factors which have direct bearing upon quality control. Research in the subject area can guarantee the technical accuracy of the broad content of a program, but the selection of the appropriate interpretation requires a detailed analysis of the material. In order to present the subject matter in a manner which is suitable to the intended grade level, it is often necessary to present highly complex concepts in simplified form. The simplified version must still be consistent with the accepted concept or theory, and there is always the inherent danger of oversimplification. If it were easily possible to state a comple theory in simple terms, the theory would not be complicated in the first place; yet, this is a problem the programmer must solve.

The quality of a program is directly dependent upon the reliability of the subject matter. The overall development of a highly involved concept must be simple and logical, but, at the same time, each frame must be able to stand alone as presenting accurate information under tight stimulus control.

Experience has shown that the production of a program of high quality requires the diverse talents of many skilled individuals: the psychologist, as the authority on programming techniques; the subject-matter consultant, as the authority on content accuracy; the programmer and editor, as the coordinators and constructors of the program.

The subject matter of any program must be presented in a writing style which is appropriate for the intended grade level. The extent of the student's vocabulary must not be overreached; yet the level of word content must be high enough so that the student does not feel that the program is in any way patronizing his intelligence. Any program, on any subject, written for any grade level, should be grammatically impeccable.

A program requires intense concentration on the part of the student. Although attention span increases with increasing maturity, any program written for any level must change pace in some fashion to provide a break in the concentration required by the program, but no break in the continuity. The use of humor is reasonably appropriate in programs written for lower grade levels, yet the humor should be related to the content of the program. Programs written for higher grade levels may more appropriately use other means of providing a change of pace. This may be done by momentarily lowering the level of response called for in some frames. A sequence which develops a difficult concept and requires maximum concentration may be followed by a few such frames; then the tempo and level of response can be increased as a new sequence is developed.

The programmer must concentrate equally on the subject matter and the programming techniques by which the subject matter is presented. The frame should include no irrelevant material; every bit of information given should be essential for the student to be able to make the response. If the student does not need to use any of the information, it should not be in the frame. Conversely, the response should be a direct check of information given in the stimulus. The response called for in the frame should always be the critical response. If, for example, the stimulus states that $X=Y$, and the equality of X and Y is the critical piece of information, then the student should be called upon to respond in some way concerning the equality of the two rather than to complete a statement such as $X = \_\_\_$. If the emphasis is on the fact that Y, a new fact or concept, equals a previously taught or known X, then the response should be in terms of Y rather than equality. The selection of the critical response is an extremely significant and extremely difficult part of the art of programming. A programmer frequently writes the response first, then tailors the stimulus to fit the response.

The relationship between response and stimulus is reversible; that is, the response called for should be the one of primary importance, and the stimulus should present the information so that the response is under stimulus control. If any response other than the one given in the confirmation can rightfully be made, the response is not under stimulus control and the stimulus is improperly stated. The stimulus portion of the frame should be constructed so that one, and only one, response is appropriate.

If the programmer is satisfied that the response called for is the critical one and is the only response which is appropriate, he must still examine the stimulus to see if there is any way the student can make the right response for the wrong reason. In the initial development of a new concept, it is frequently necessary to cue the response rather heavily, so that the frame is in essence a copy frame. As a teaching sequence develops, the intentional prompts are gradually withdrawn. However, the programmer must constantly be on the alert for internal cuing which allows the student to respond correctly because of some extraneous stimulus. An unintentional internal cue may take many forms. It may be a grammatical cue, such as placing "an" or "a" before a blank. If one of two alternative responses starts with a vowel sound, the student can automatically make it if he sees "an". If he sees "a", he can, again automatically, respond with the word which starts with a consonant sound. The same grammatical construction may always have been used to state a certain fact. In this case, the student may be responding to the phraseology of the stimulus rather than to the information given in the stimulus. Many programs necessitate the use of diagrams, and this compounds the problem of internal cuing. Is the student responding to the intended stimulus, or is he selecting his response on the basis of an arrow that points to the right rather than to the left? Diagrams should be varied, should contain as few cues as possible, and should be used only when it seems impossible to present the stimulus adequately without one.

A program must be thoroughly tested before it is released. A preliminary pilot testing of the first section of a program is frequently made to check on the correctness of the writing level. It is essential, especially when writing for lower grade levels, to test such factors as depth of vocabulary and difficulty of grammatical construction as well as clarity of presentation. A thorough analysis of the testing results obtained on the complete program must be made and the program revised accordingly if necessary.

What criteria may be used to aid in the selection of a well-constructed program? Ideally, the entire program should be read from start to finish. The prospective purchaser can then best judge whether the program covers the intended topic area and in fact teaches the essential material in the proper sequence. A study of only the first part of a program usually does not give a true picture of the program as a whole. A program presents material in a way which is new to the student. He must first learn to use this new tool; consequently, a program frequently starts slowly and may seem to present its material in an unnecessarily elementary fashion. Once the student has been given time to accustom himself to these new techniques, the tempo can, and does, increase. If individual frames are inspected, each one can be analyzed as to its internal construction: relevancy of information, appropriateness of response, stimulus control, internal cuing, etc. A block of several frames may be studied, to look for the orderly development of ideas. Does each response demonstrate an increase in the student's knowledge? Is the concept developed fully? Is the student given numerous examples which illustrate the application of the concept or rule? Is he taught to use his new knowledge?

Factual evidence should be presented which demonstrates that learning occurs as a result of the use of the program. For example, a comparison of the scores obtained on identical subject-matter tests, administered prior to and following the use of the program, should show a significant gain in the student's knowledge.

The program should also be viewed from the standpoint of its interest to the student, and a careful study should be made concerning the manner in which the subject matter is presented. The program should include a variety of frame styles so that learning without boredom is the result. However, the program should be well balanced: enough variety to provide interest, but not so much that the student can become confused from trying to determine, not what the response is, but how he is supposed to make it.

Above all, one should look for the deceptive simplicity of the program. Some of the features which may be used as criteria have been mentioned; if it progresses logically, has good stimulus control, teaches easily and thoroughly, covers its intended topic area, and holds the student's interest, it is a well-constructed program.

SKINNER TECHNIQUE IN REINFORCED LEARNING AS APPLIED TO REMEDIAL SPELLING

Glenn H. Rogers

Glenn H. Rogers reports an experiment to improve the spelling ability of college students. An extensive readiness program was followed by the use of programmed material. A small sample of five students improved spelling ability from a mean of 34% on the pre-test to 99% on the post-test.

This experiment was conceived as an attempt to improve grade averages of a group of students in basic English classes who were substandard in spelling. Subjects were selected from volunteers recommended by instructors of these classes. The final group of subjects consisted of those whose spelling responses placed them below the 50th percentile as measured by Freshman's spelling tests.

The technique known as "reinforced learning" developed by Dr. B. F. Skinner of Harvard University was utilized in this experiment, after both visual and auditory conditioning of the subjects. The Skinner linear approach was applied through the use of auditory stimuli presented via tape recorder.

In a series of pre-tests it was discovered that students with spelling ability below the 50th percentile had nearly 100 percent visual imperceptibility, and in most cases, faulty phonetic perceptibility. Subjects could neither see mentally the simplest symbolization, nor could they accurately identify auditory stimuli with the proper symbolic counterparts. This was especially true where words contained vowels or vowel blends. This phonetic anolamie is present in areas where the production of English vowel sounds, in some cases, is distorted. Visual imperceptibility was established as a basic fault when subjects, while blindfolded, were unable to accurately draw simple figures such as a cross, square, circle, or triangle on a chalkboard.

Having determined the presence of both the visual and auditory limitations in the subjects it was decided to incorporate a readiness program consisting of phonetic and visual training before applying the Skinner technique. Visual imagery was sharpened by having subjects "see clearly" familiar objects about their homes, rooms, garages, and yards. Each was asked to shut his eyes and mentally "take a walk" around his home grounds, to enter the house, to go carefully from room to room, seeing each familiar object in detail. This "tour" was accompanied by audible descriptions, with frequent questions by the tester designed to elicit detail.

Vowels and consonant symbols were then placed on a blackboard and subjects were asked to reproduce each several times, visualizing the symbol mentally, and with clarity. Individual symbols were then combined first into short words, then into longer ones. The practice of visualizing clearly was continued throughout the experiment, and preceded each group of presentations during the programming.

Phonetic identifications are important in a spelling lesson which is presented as auditory stimuli. Whether the stimuli originates as "imagery" or as auditory vibrations impinged upon the tympanic membrane is not important. In either case accuracy in spelling demands that the auditory phoneme or combination of phonemes be properly identified with the symbolic counterparts in all the variegated forms found in the English language.

Example: the Phoneme "u" is the same in "stew", "too", "soup" and "through".

The knowledge that English is a polyglot language and thus contains many words that do not even approximate the sounds being represented does not assuage the harassed student to whom "boat", "mote", "stow", and "though" all look pretty much alike vowel-wise.

As a part of the readiness program in this experiment these students were given a basic lesson in phonetics, with repeated drills on the vowel phonemes. These phonemes were presented audibily at the same time their symbolic counterparts were presented visually, in all existing variations. Once the students learned that *there are seventeen basic vowel sounds, not five as they had supposed* and *three basic diphthongs,* the establishment of sound identification to vowels and vowel combinations was not a difficult one. Addition of consonants followed quickly.

Students were considered "visually ready" when they could reproduce clear mental images. They were considered "auditorily ready" when they could recognize, identify and reproduce vowels, consonants and unphonetic combinations with accuracy. The entire readiness training consumed only four periods.

A readiness program for a remedial spelling project cannot neglect the semantic component. In the list of words selected for presentation, most were found to be in colloquial usage, and needed only contextual association to explain their meaning. This was provided during the initial pronunciation, and further presentation of the words.

Presentation of the Constructed Response

Five students were used in the experiment. A list of 1000 hard-to-spell words compiled from Shaw (1961) was used. Initial tests were given and scored. Following phonemic and visual readiness training, the linear method of constructed responses was used to present 200 words classified as "difficult to spell".

These were presented via a mechanical device called a "Cyclo-teacher" published by Field Enterprises Educational Corp., publisher of World Book Encyclopedia. This consists of a revolving disk on which is placed a work wheel containing fifteen constructions on each side. The Subject reads the construction, writes his answer in an appropriate box, turns the wheel and checks with the correct word which appears in a window. Each word is presented three times in variable patterns designed to emphasize the "difficult" segment of the word.

Example:

Construction	*Response*
His N__ghbor made periodic visits to check his welfare.	n*ei*ghbor
His closest n__ghbor lived three miles away.	n*ei*ghbor
He had been a good neigh__ for twenty years.	neigh*bor*

Subjects were required to repeat each wheel in which an error occurred.

The major segment of this training consisted in the presentation of words via auditory stimuli, using a tape recorder. The linear approach was used, and emphasis on repetition, frequency, and reinforcement of immediate reward was applied.

Words were grouped germanely, when possible, into both phonetic and unphonetic patterns. Words in a group were related pictorially. This type of grouping, following the principles of repetition and frequency, aided in establishing the visual responses.

Example of pictorial grouping:

ei words	ence endings	tion endings	ur endings
ie words	ance endings	cion endings	or endings
	ents endings	sion endings	er endings
			ir endings

Both General American and phonetic pronunciations were used. The phonetic pronunciation, it was felt, aided in establishing auditory identifications with the correct visual image. Example, the word "analyze" would be given normally and also "anal-wize" to emphasize the "y" spelling. The word "accommodate" would be given "ac'com'mo'date" to emphasize the phonetic breakdown. Semantic components were not ignored as identification factors. Where necessary, a word was used in an appropriate simple sentence to establish an interpretation and meaning.

In the presentation of the words, frequency was considered an important factor. In a given word the frequency was accelerated at the beginning of a group presentation, for example:

A A B A B B C C B A B C D D

Each word was presented four to six times in a grouping.

Students worked both individually and in groups. The taped presentation can be considered auto-instruction as it was not necessary for an instructor to be present. Each word group was given a number, which was easily located on the counter-dial built into the tape recorder. A word group was repeated by a student only when he felt this necessary. Following the completion of each word group, a final test of the word list was given.

Results

After an average of 30 hours auto-instruction, which followed pre-conditioning, the five subjects showed an average net gain of 64.5 in correct responses. Students worked individually and in groups, and were able to complete the 88 groups in eight weeks, operating the tape recorder one hour per day three to four days a week. Because of the limited number of tape recorders available, students worked at night, on week-ends and other odd times.

Subjects moved from initial average of 34.36 correct responses to 98.72 correct responses in the experiment. The greatest gain was from 27.7 to 99.3. Subjects moved through the 88 groups of 1000 words without an intermediate testing period. The final dictation was given following the completion of the eight tapes used in the experiment.

Retention

The weakness of this experiment was in the inability to make an accurate evaluation of retention. At the close of the experiment the Spring semester was over, and school was out. It is to be noted, however, that

Table I

Reduction in error during auto-instruction

Student	*% Error Initial Test*	*% Error Final Test*
A	53.8	0.009
B	61.2	1.4
C	72.3	0.007
D	68.7	1.6
E	72.2	1.8

no intermediate testing was applied, and in the final test, the words presented at the beginning of the experiment showed no greater tendency toward inaccuracy than words presented nearer the close of the experiment.

Negative Correlation With Mental Ability

Table III shows correlation of "mental ability" with percent of initial error. Otis Mental Ability tests: Gamma AM were presented to these subjects. Results of this testing do not indicate any significant positive correlation between low spelling deficiency and subjects' ability to make correct responses on the Otis MA tests. It is to be noted that all IQ scores, as indicated by the Otis tests, fall within the range established as "normal" i.e. between 90 and 110.

Table II

Percentage of gain in correct responses during auto-instruction

Student	*% Correct Initial Test*	*% Correct Final Test*	*Net Gain*	*Hours spent Auto-instruction*
A	46.2	99.1	53.7	30
B	38.8	98.6	59.8	32
C	27.7	99.3	71.6	25
D	31.3	98.4	67.1	35
E	27.8	98.2	70.4	32

Table III

Correlation between initial test results and scores of Otis M/A tests. Gamma AM.

Student	*% Correct Initial Test*	*% Correct Final Test*	*Raw Score/ I.Q.**
A	46.2	99.1	51/109
B	38.8	98.6	43/101
C	27.7	99.3	42/100
D	31.3	98.4	44/103
E	27.8	98.2	42/100

ADJUNCT PROGRAMMING

M. A. Zaccaria and Lt. Charles F. Adams, USAF

M. A. Zaccaria and Charles Adams start by questioning the importance of written responses and immediate knowledge of results. They state that these features of programmed instruction are not always necessary for effective learning. On the basis of Air Force research, they raise considerations of economical, efficient adjunct programs. An adjunct is basically a series of objectives in question form. The questions are given to the student and direct his attention to the key points in the content of the basic narrative text.

In spite of the fact that most experts in the field of programmed instruction seem to explicitly state or imply that real learning takes place only with a private tutor or through programmed instruction, hundreds of millions of people have been learning knowledges and skills in the past without either method. These millions of people have been learning from books, classroom lectures, by trial and error, and such other methods as all experts in programmed instruction abhor. True believers in programmed learning must come to grips with the hard reality that the vast majority of learning in the past, and for a long time in the future, will take place without benefit of programmed instruction.

How can we improve the efficiency of education and training that will continue to be accomplished with unprogrammed instructional materials? How can we increase the amount of learning that takes place without the assistance of or through the media of programmed instruction? How can we increase the awareness and appreciation of the principles of programmed learning with students, parents and administrators? And how can the vast majority of education using unprogrammed materials be improved until it is consigned to oblivion through complete replacement by programmed instruction from kindergarten to the Ph.D?

Let us begin by questioning some of the hallowed principles of programmed instruction. Linear program theory is based on several assumptions that have not always been substantiated by research or evaluative studies. For example, studies conducted at Lackland AFB, University of California, at Los Angeles, and Stanford University indicate the students do not have to respond to each frame for effective learning; in fact, no written response at all may be as effective as making constructed answers. This finding has both theoretical and economic implications.

The assumption that a student should be reinforced by being shown the correct answer each time after he responds has been questioned by recent studies. The application of this finding can make for more efficient use of time and equipment.

Some amazing findings have evolved from informal developmental studies. Programs have been constructed that merely divide the written material into small segments with a key word to be constructed by the student. Even though the material is not considered to be well sequenced or programmed, the program teaches quite effectively. In fact, one may learn to make appropriate responses in a criterion test, even when he practices the irrelevant responses for which the programmer has left a blank. It appears that the mere breaking down of information calls for enough attention of the learner so that he learns, at least in some kinds of situations.

Recent studies at Lackland Air Force Base have indicated that an adjunct program can be less costly to develop and administer and yet produces as much learning as a conventional program. This program asked questions of the student for each paragraph of text. The learner was forced to analyze the printed material and to write his answer to a question that tested his knowledge of the paragraph. Student completion time was half that of the corresponding linear program. The questions, in effect, became the course objectives. We hypothesize that the student realized that the questions were his objectives and motivated himself to learn them.

There are many possible ways of developing adjunct programs to already existing texts. The main service these adjuncts would provide is to call attention to the educational or training objectives. One method of presenting an adjunct is to list all of the relevant test questions for a text. A refinement of this is to indicate on which pages and in which paragraphs of printed materials the answers can be found. A further refinement could be to develop branching or by-pass questions. Another technique is to develop a linear program to give students certain basic knowledges such as terminology; this could be used in conjunction with questions on the text. Although the authors prefer to use constructed response questions, they know of no reason why appropriately developed multiple-choice questions could not be developed.

There are a number of advantages for using adjunct programs over the conventional linear, intrinsic, and mathetical types. Adjunct programs are less costly to develop. As content changes, they can be readily modified or revised and be easily and quickly published. They are more relevant to everyday work and learning situations and there is less fear of providing students with a crutch. One cannot ignore the fact that there would be less resistance to this technique on the part of both teachers and students.

The authors realize that adjuncts are not necessarily new ideas. They are not sure that their concepts are drastically different from those of Pressey's back in the early 1930's or of the workbook. They are not as concerned, however, with presenting new ideas as they are with making education and training more effective. This is a pragmatic approach. Anything that works is good. Adjuncts are not panaceas for all instructional problems. They are merely presented as one possible practical and economic consideration for effective learning.

A CONSIDERATION OF SOME OBJECTIVE PROPERTIES OF LINEAR PROGRAMS

B. W. Yaeger

Bernard Yaeger points out that programmers have few objective tools available during the initial preparation of material, depending instead on student tryout information to shape the eventful field version of the program. He discusses several experimental procedures and their apparent effectiveness.

One of the problems facing a program writer as he prepares a linear type program is the lack of objective measures to use as yardsticks or guide lines. Although an experienced programmer does develop some "intuitive feel" for his task, this feeling should be rendered objective and preferably quantifiable. The programmer begins by shooting in the dark, particularly in regard to step size. Normally this is a very subjective process and is based upon the programmer's subjective opinion of a "step" and of a student's ability to take that "step". Before these opinions can be verified by tryout on actual students, the programmer must proceed by his intuitive feelings, in regard to step size, rate of progress, repetition, relevancy of responses, etc. The approach that an appropriate size of step is that size which yields a 5% error rate is useless at this point. What the programmer needs is before-the-fact information on step size rather than after-the-fact results obtained during the tryout. Besides an objective measure of step size, the programmer also needs to know the amount of repetition or response redundancy to build in and ideally some measure of difficulty, if one can be found. These objective measures would also be helpful in preparing corrective sequences or in preparing a series of tracks for multi-track programs.

With multi-track programs we can accommodate students of different abilities, backgrounds and experience levels more effectively. For example, we could provide a fast track program at a high level, one alternative sequence of an intermediate level and a third alternative sequence at a low level. We could use then the same program for a wider range of students and in a wider range of situations. Also, material could be used for a variety of different purposes, such as original learning, review, and for refresher training. We could write this kind of program with much greater accuracy by using the objective measures as a guide; that is, by using objective measures, we could improve the appropriate parameter with assurance that other parameters were not at fault. This would assist the programmer by permitting more efficient use of his time and by providing him some assurance that the program was near the target. Effective measures could be used before student tryout, and would be very helpful when students are not readily available.

One of our objectives in this type of research is our interest in the utilization of programmed material in teaching machines. The closer we are on the first try, the fewer times we will have to revise material for machine presentation. This process will almost always be more expensive than the rough typing on index cards approach. Currently, the advice to the programmer continues to be, "write some frames and try them out" and let the student dictate answers to these problems. But this approach is likely to require an impractical number of trials. So what objective measures can we use before-hand? Let me say first that any before-the-fact measures will not be completely sufficient and usable by themselves. Every program need to be tried and verified on actual students. This tryout generates an error rate measure of step size and a final test indicates whether or not the student has learned. Better still is on-the-job success. But obviously we cannot wait for the on-the-job performance to verify a program or to indicate that our seat-of-the-pants feel for step size, repetition and difficulty was correct. What is needed is one or more objective measures, independent of student performance, which can serve as guide lines in program preparation..

We at Honeywell have begun some exploratory research in this area. This research is far from complete, but thus far has yielded some interesting data. Some of our initial ideas we are now fairly certain will not work, and we have some information on other ideas that look like they will work. The first of these is program density. This is an approach proposed by Edward L. Green of Dartmouth in his book "The Learning Process and Programmed Instruction" (1962). Program density is the ratio of the number of different responses to the total number of responses made. For example, if each response term was called for twice, the density ratio would be .50. If no response was called for more than once, the ratio would be 1.0, or unity. Green proposes this measure as an indication of the rate at which new material is introduced. We have interpreted it as a measure of repetition, and as an indication of difficulty. Green found that program density was significantly related to error rate ($r=0.47$, $P.005$). The denser the program the higher the error rate.

The second independent measure we looked at, and this is one which does not appear worthwhile, is the number of responses per frame. We looked at this as a measure of step size to test the hypothesis that a step is the distance between responses. The third measure again relates to step size and is a count of the number of sentences per frame or per step. Is step size measurable in terms of number of words? The fourth measure is an indirect measure of difficulty. We asked, "Is it possible that readability is related to difficulty, error rate, etc?" We selected the Gunning (1952) readability index or "fogcount" as the objective measuring device. This is an empirically derived formula which counts the average number of words per sentence and the number of 3 syllable words per 100, and yields an index which is related to school grade equivalent.

Let's examine several samples of published programs with these independent measures.

Example 1:

Title—	"Plane Geometry"—106 frame sample
Author—	Edward B. Curtis
Published by—	Encyclopedia Britannica Films TEMAC
Population—	9th grade
Density—	.62 (all responses; numerical and verbal) .51 (verbal response only)
Responses/frame	1.13
Sentences/frame	1.71
Readability	8.33

Note the density ratio of .62 for all responses and .51 for verbal or word type responses only. This shows an average of 2 responses for each response term used. Note also the readability index of 8.33. The author aimed for a 9th grade population and his readability index indicates that he hit the mark, i.e., between 8th and 9th grade.

Example 2:

Title—	"Descriptive Statistics"—78 frame sample
Author—	Teaching Machines Inc.
Published by—	TMI—Grolier
Population—	College population and bright high school students
Density—	.38
Responses/frame	2.16
Sentences/frame	2.55
Readability	12.0

The TMI program shows a lower density, .38, but note the number of responses and number of sentences per frame. They are both higher than the TEMAC program. The readability index of 12 or 12th grade indicates that the TMI authors also hit their mark as far as reading difficulty is concerned.

Example 3:

Title—	"The Analysis of Behavior"—Set 1-3 inclusive (114 frames)
Author—	Holland, J. B. and Skinner, B. F.
Published by—	McGraw Hill
Population—	College
Density—	.33
Responses/frames	1.29
Sentences/frames	1.25
Readability	14.9

"The Analysis of Behavior"—Set 1 only (54 frames)

Density	.27
Responses/frames	1.40
Sentences/frames	1.25
Readability	1.25

This is probably one of the best-known programs included in our analysis. Note the still lower density ratio. Also note the sentences per frame rate. When Holland and Skinner proposed the use of small steps, they meant small! Out of 100 frames only 25 have more than one sentence each. Contrast this with the TMI program which averages 2.55 sentences per frame.

Let's look at a few others also.

Example 4:

Title—	"Earth"—36 frame sample
Author—	AIM Staff
Published by—	Accelerated Instruction Methods 179 N. Michigan Ave. Chicago 1, Illinois
Population—	Jr. High School
Density—	.39
Responses/frame	1.28
Sentences/frame	2.11
Readability	7.17

Note density at .39 level and readability at the 7th grade level. Here again the authors hit their population target as measured by the readability index at any rate.

Example 5:

Title—	"AC and W Radar Repairman"—97 frame sample
Author—	Inman & Kelley
Published by—	ATC—Keesler AFB
Population—	ATC Radar School Students
Density	.23
Responses/frame	1.57
Sentences/frame	1.5
Readability	10.4

Final Tryout—20 students
Error rate average—2.5%
Final test average—91.56% correct

This is a course developed by ATC in-house instructor personnel. Note the low density ratio compared to the first three programs but note also the low error rate. The student population were all high school graduates so the readability figure of 10th to 11th grade could be handled easily.

Figure 1 Summary of Program Analysis

	TEMAC	*TMI Grolier*	*Holland & Skinner*	*AIM*	*ATC-Keesler*
Density	.62	.38	.33	.39	.23
Response/ frame	1.13	2.16	1.29	1.28	1.57
Sentences/ frame	1.71	2.55	1.25	2.11	1.5
Readability	8.33	12.0	14.9	7.2	10.4

We can compare these programs against each other to note the variation in our 4 objective measures. We would like to urge caution in drawing any conclusions at this stage in our analysis. With the limited data thus far collected we are not certain yet how valid these measures are. We are not certain yet what artifacts may be present, what sample size is required, or whether programs at various levels have the same correlations with student data. As mentioned previously, these data cannot be used without correlation with after-the-fact data such as error rate, final test scores, student opinions, etc. These kind of data we have not yet collected.

A readability index appears at this stage to be a reliable and valid measure. If the readability index is say 12, the program will probably be difficult for 6, 7th and 8th graders. Conversely if a college program has an index of 6 or 7, the presentation will be aggravatingly slow and probably boring to that level of student. The sentences per frame do not appear to or indicate much at this time. Since sentence lengths may vary considerably, we also tried "number of lines," but without success. Words also did not appear meaningful. A better measure might be the number of ideas or S-R associations, but these are too subjective. Some volume measure which correlates with size would be helpful, but thus far we have not found one.

The responses-per-frame measure indicates that, on the average, informational frames were not used very frequently. This measure does not appear to be of significance at this time. Further exploration of the reading vs. responding experiments may reveal data which will indicate the number of responses which are necessary or beneficial. The density ratio measure appears to have the most significance at this stage in our research. Logically it looks good and theoretically it appears sound. Correlations between density and student level, error rate, final test score, and retention need to be determined. Comparison of several different density ratio programs, say ratios of .20, .40, .60, and higher, need to be prepared and tested. If significant correlations are again found, alternate-tract programs can be prepared on the basis of density and a significant objective measure and programming tool will have been discovered.

SOME GENERAL RULES OF FRAME CONSTRUCTION

Stuart Margulies

Stuart Margulies draws a distinction between "critical response" frames, and what he calls "everything" frames. In the critical response situation, the student is assumed to know only that material to which "he has responded" correctly. A student reading an "everything" frame is held responsible for every item of information in the frame, even if it is irrelevant to program objectives. Implications of the critical vs. everything distinction are pointed out, particularly as they apply to rules for response cueing. Stuart Margulies contends that the critical response principle is consistent with laboratory devised principles of learning.

INTRODUCTION

The present paper is directed to the identification and analysis of some general rules of frame construction. These rules allow us to recognize and correct the deficiencies in such frame sequences and single frames as the ones below:

1.
a. Because of its inefficient cutting arm, the layman reaper can perform only 120 operations. A total of 360 operations would require______ reapers.
b. The layman reaper is restricted to 120 operations because of inadequacies in its______________________.
c. Because of its cutting arm, only 120 operations can be obtained from the___________ reaper.

2.
The immediate use of goods in return for the promise to pay later is characteristic of a purchase made on credit.
"Fly now, pay later" is an example of a purchase made on___________.

3.
Cortical convolutions increase as we ascend the phylogenetic scale.
Thus as we ascend the phylogenic scale we observe an___________(increase/decrease) in the number of cortical convolutions.

ANALYSIS OF SIMPLE FRAMES

Before examining the faults in the frames above, let us consider frames 4 and 5 below. These two frames illustrate in an exaggerated fashion two contrasting philosophies of frame construction. The purpose of both frames is to teach the information that the symbol * is the equivalent of plus.

4.
* is the equivalent of plus
4 * 3 = ________________

5.
* is the equivalent of plus
4 + 3 = ________________

Both of these frames adhere to generally accepted tenets of programming technique. They present small units of information, require active responses and may be arranged to give immediate reinforcement. Yet most people would intuitively select frame 4 as preferable to 5; they would agree that frame 5 can teach, but would feel that frame 4 can teach better.

This intuitive preference is amply supported by the theoretical arguments of the learning theorist. The shaping process requires that the experimenter build only on established behavior. Frame 4 is satisfactory because a correct response requires mastery of the material presented; the writer is therefore able in later frames to build upon the concept that has been taught. Frame 5 must be rejected because a correct response need not indicate understanding of the new information.

CRITICAL PROCEDURE VS. EVERYTHING PROCEDURE

Implicit in the preceding discussion is the following principle, which is held here to be the fundamental rule of efficient frame construction:

In each frame, a student can be held responsible only for that portion of the presented material to which he has responded correctly. Subsequent frames may build only upon such material.

This principle will be referred to as the "critical response" or "critical" principle and may be contrasted with a second position, which will be called the "everything-is-learned" or "everything" principle. The "everything" principle, of which frame 5 is an illustration, may be stated as follows:

In each frame, a student may be held responsible for all material presented whether or not he utilizes this information

in making an immediate response. Subsequent frames may build upon all material presented.

An analysis of the following simple frame sequence may be useful in illustrating the differences between the two contrasting principles.

a. * is equivalent to plus.
  * was used by the Greek, Thesalius.
  3 * 4 = ____________
b. Name the Greek who used the symbol *.
  ____

This frame sequence is consistent with the everything principle, but violates the critical principle because material called for in frame b has not been responded to in the preceding frame. Violations of this fundamental rule occur quite frequently in the work of inexperienced program writers, but are rarely so blatant as in frames a and b. A more typical example was given in the introduction section of this article and is reproduced below:

a. Because of its inefficient cutting arm, the layman reaper can perform only 120 operations. A total of 360 operations would require ________ reapers.
b. The layman reaper is restricted to 120 operations because of inadequacies in its ________
c. Because of its cutting arm, only 120 operations can be obtained from the ____________ reaper.

Again, material called for in frames c and b has not been correctly responded to in preceding frames.

PROGRAMS VS. TEXTBOOKS

Learning from textbooks is based on much the same principles as learning from programs constructed on the everything-is-learned rule, because in both cases the student is expected to read and retain all presented material. The active response required by the everything program is not very important; the student is responsible for material to which he has not made an active response. Theoretically, then, a student might learn as well by reading such programs with the response blanks filled in as by going through the programs and making all the correct responses.

This fact may partially explain those surprising research results which indicate that students who read through a "program" with the response blanks filled in do as well in post-test performance as students who go through the program making all the required responses. These studies invariably conclude that student responses are not critical to learning; such results may actually be attributable to the fact that the programs thus studied have utilized everything-is-learned, rather than critical-response, procedures.

In an everything program, there may be no significant difference in the post-test performances of those students who are required to respond and of those students who are given no opportunity to respond. In a critical program, the student required to respond may be expected to achieve better results than the student who merely reads.

In other words, in a critical program, active responses are integral to learning, while in an everything program, they are not.

COMPARISON OF "EVERYTHING" VS. "CRITICAL" PROGRAM

The everything-is-learned program can result in satisfactory post-test performances, just as inefficient textbooks may result in learning. However, it is the contention of this paper that everything-is-learned procedures result in less motivationally sound and less pedagogically efficient learning than do critical-response procedures. Critical-response program sequences employ the laboratory principle of shaping in that they build upon reinforced behavior. Everything-is-learned programs, on the other hand, require an inefficient expenditure of student time and demand study skills which few readers possess. The student must painfully read and reread each frame, attempting to master any element which might be significant. He may discover that he will later be asked about some, but not all, of the material which is included in a frame. In this event, he may begin to learn selectively. And he must decide which information, apart from that which is required in the response, is important and most likely to be called for in subsequent frames, even though, as Mechner has pointed out, the student is often new to the subject matter area, and far less competent than the writer to judge what is important.

USE OF SUPPORTING MATERIAL

It may seem that the writer of everything frames has greater opportunity to introduce illustrative supporting material; after all, he counts on the student to read, study and retain every element in every frame. Paradoxically, the contrary is true. The everything writer must often limit himself to a sparse presentation because he may otherwise cause the student to devote himself to learning material intended only for illustrative purposes. Consider the following frame, which teaches the delivery of material requires 10 days.

It requires 7 days to pack and assemble material after the request is made.
It requires 3 days to label the material for delivery.
How long is the time between request and delivery?__________.

This frame offers no problem for the critical-response writer who holds the student responsible only for learning that delivery takes 10 days. However, the everything-is-learned writer who introduces such material faces the problem that the student will study all the supporting information in preparation for subsequent frames which may ask how much time is required for labeling, or which operation requires 7 days. This information may be useful for illustrative purposes, but unworthy of retention.

RULE OF CUEING

According to the critical-response rule a student may be held responsible for material to which he has responded correctly. It is clear, however, that a correct response may indicate only a limited mastery of the presented material. This leads to an important corollary to the critical-response rule. It is formally stated below:

A student is held responsible only at the minimum level of understanding required for a correct response to a frame.

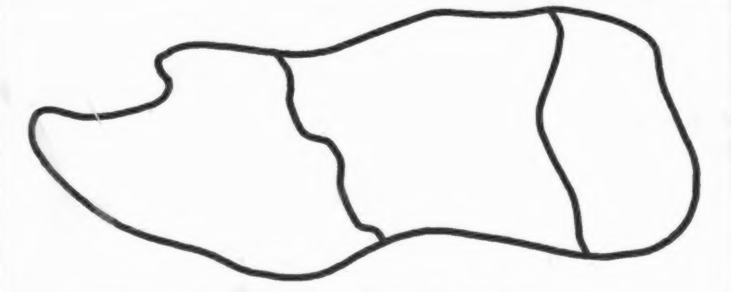
The practical implication of this rule is that the programmer may not assume conceptual understanding when the student is responding to extraneous cues. The following frame illustrates this danger:

All Gaul was broken into THREE divisions. Thus Gaul consisted of T _ _ _ _ parts.

Here the student can respond correctly without really reading or understanding any of the material presented in the frame. This frame is functionally identical to a frame which reads:

Copy the word THREE.__________

For this reason, several writers have termed such frames as "copy-response frames". The disadvantage of such frames is that they are inefficient. In the example above, the student receives practice only in copying the word "three" rather than in learning that Gual is divided into three parts. More efficient ways of writing the above frame are:



This map shows the division of Gaul.
Into how many parts was Gaul divided?______.
Gaul was divided into parts occupied by the Celts, the Belgae and the Acquitani.
Into how many parts was Gaul divided?______

(Note that by the critical-response rules given above, the reader need not learn the names of the Gallic tribes.)

DANGERS OF INADVERTENT COPY FRAMES

Learning theorists point out that concept formation is dependent upon maximum generalization within a class. Copy frames adhere to the anti-thesis of this principle because the student reading a copy frame repeats the information presented; he does not sample from the wide range of instances which define the class.

The failure to properly develop conceptual understanding is not limited to frames employing such blatant cues as T _ _ _ _. Markel and Mechner have pointed out that there are many subtle ways in which a frame writer can inadvertently give away the correct response and thereby transform what might otherwise be a well cued frame into a copy frame. (This topic has also received extensive treatment in the field of test construction.) The following frame contains an example of a subtle giveaway cue:

The immediate use of goods in return for the promise to pay later is characteristic of a purchase made on credit.
"Fly now, pay later" is an example of a purchase made on__________.

Here, the phrase "purchases made on" preceding the word "credit" in both sentences clearly gives away the desired response, and serves to reduce the frame to a copy frame.

TECHNIQUE FOR APPROPRIATE CUEING

The relationship between a copy frame and a properly cued frame is continuous rather than dichotomous; a frame may be more or less cued, and the desired response may be more or less given away. A useful technique which maximizes generalization and serves to ensure meaningful utilization of new materials is to require that each restatement of a concept utilize new terms and, when possible, new perspectives. Consider the examples below, each of which attempts to teach the concept that cortical convolutions increase as we ascend the phylogenetic scale. (It is assumed in these examples that all the pertinent terms are familiar to the target population.)

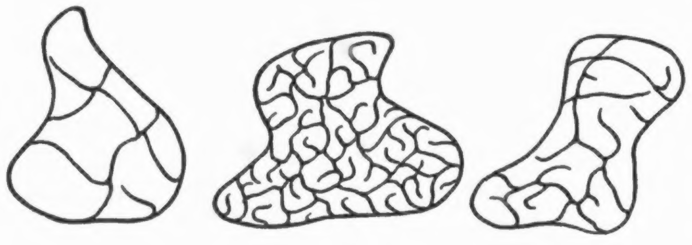
1.
Cortical convolutions increase as we ascend the phylogenetic scale.
As we ascend the phylogenetic scale, cortical convolutions____________(increase/decrease).

2.
Cortical convolutions increase as we ascend the phylogenetic scale.
As we ascend the phylogenetic scale, cortical convolutions become____________(greater/smaller).

3.
Cortical convolutions increase as we ascend the phylogenetic scale.
As we go from lower organisms to higher organisms, the number of cortical convolutions becomes ____________(smaller/greater).

4.
Cortical convolutions increase as we ascend the phylogenetic scale.
A platypus is a mammal. Which has the greater density of brain furrows, a platypus or a duck?
____________.

5.
Cortical convolutions increase as we ascend the phylogenetic scale.
The diagram below represents cortical sections from a lizard, a duck and a rat. Write the name of the appropriate organism below each diagram:



____________ ____________ ____________

Frame 1 is clearly a copy-response frame, frame 2 represents a slight improvement because it used the words "becomes smaller" instead of the word "decreases." Similarly, frame 3 is a considerable improvement because many of the terms in its second sentence have been changed, while frames 4 and 5 contain sufficient variation to be considered acceptable.

SUMMARY AND CONCLUSION

Critical-response procedures employ laboratory derived principles of shaping. The student is held responsible only for material to which he has responded correctly and, as a corollary, only at the minimum level of understanding required for such responses. Conceptual understanding is aided by the presentation of each restatement of a concept in new terms and, when possible, new perspectives.

In a critical program, responses are, then, an integral part of learning. In an everything-is-learned program, they are not, and the student reads and rereads frames, attempting to master even unessential illustrative material. Critical-response principles can be used to correct a wide range of deficiencies in frames and frame sequences. Programs that employ these principles build upon reinforced behavior, and are consistent with laboratory derived principles of learning.

CONSTRUCTION OF AN ACADEMIC PROGRAM FOR SCHOOL CONSULTANTS IN PROGRAMMED LEARNING

Herbert H. Hughes

Concerned with the mounting evidence that representatives of publishers, industry and the military are not communicating effectively with teachers and administrators in schools, Herbert Hughes of Colorado State College proposes a program for educating programmed learning consultants at the graduate level.

Issues raised by programmed instruction will eventually be fought in the broader context of learning and education, and it is time for leaders in the new movement to recognize this situation and direct more attention to it. The assumption that all programming experts have to do is to make materials available, and teachers will automatically accept the materials and the philosophies undergirding them, may be misleading. It must not be forgotten that education has been literally full of "panaceas" and "breakthroughs," many of which have been buried in a few short years.

To insure its lasting influence on education, programmed instruction must be merged with learning and education not merely through theoretical work and programmed material development, but more importantly through frequent personal interaction between professionals in programming and teachers in school environments. This should be a major concern since it may be the prime requisite for survival of programmed instruction as a major influence on classroom learning.

This paper is specifically concerned with describing plans for an academic program for such consultants, and to present a rationale for its development. The end-product desired will serve as a point of departure. The man to do the job in schools will be a sort of middle-man in programmed instruction, part programmer, part teacher, and part psychologist. Regardless of his academic emphasis, he must be able to work comfortably with persons from the three specialties. He must be an effective educator because his work will be in the schools.

Financing the cost of training a person for these competencies must be considered. One possibility is to establish cooperative agreements with organizations producing programs to be marketed. To optimally and efficiently train school personnel in the various phases of programmed instruction, many institutions of higher learning may have no other choice than to establish working agreements with private programming organizations. Using the personnel and physical facilities of these organizations for practicum and internship experience makes it financially feasible for the institution to provide a well balanced academic sequence in programmed instruction.

The educational level at which programmed learning consultants should be trained must be decided. The bases for programmed instruction have been relatively sophisticated, and it is recommended that such specialized academic training should be restricted to the graduate level. Since quantity, flexibility, and quality must be considered at the present stage of the development, it has been recommended that such training be at the master's specialist (one year beyond the master's) and doctoral levels. The master's candidate would be trained to function chiefly as a liaison person between school systems and research and programming organizations. Practicum experience from one to three months in organizations developing programmed materials would be required at this level of training. Two emphases could be pursued at the specialist (Ed. S.) level, one in consulting on programmed instruction and the other in programming instructional materials. Similar coursework would be required for both emphases with the major difference lying in the nature and length of the practicum or internship. The specialist degree in consulting would be designed to provide school systems with a specialist who is qualified to provide in-service education in programmed learning, evaluate programmed materials for use in the schools, and to consult with teachers using programmed materials for instructional purposes. The specialist in programming would provide many of the same services, but would be especially trained to work with school personnel in the actual development and programming of instructional materials. Doctoral emphasis in programming would remain primarily at the minor or supporting level since there seems to be a trend for the professional in programming to remain "psychologist programmers" or "educator programmers" rather than to establish separate programmer cults. Another possibility is a doctoral major in teaching and learning technology. As programmed instruction, educational television, computer technology, and other new developments mature, it is likely that demands for highly trained personnel knowledgeable in all these areas will rapidly increase.

With a general conception of what kind of consultant is envisioned, the problem of what coursework should go into the consultant's academic program must be decided. It appears that the outstanding potential programmed instruction may have depends on the degree to which professionals in programming concern themselves with the following four points. All are of vital concern in planning specific content for a course of study in programmed instruction since they help define the programmed learning consultant's functions. (1) Those in the everyday business of education must continually examine the role of ultimate objectives or real life goals and evaluate course content, teaching methods, and student performance in the light of progress toward ultimate objectives. Ultimate objectives are in the final analysis education's reason for being. It appears that programming has encouraged excessive dependence upon objective, but short term, criteria for learning and education. Many teachers and educators also do this, but a conscientious teacher or educator has probably more difficulty than others avoiding questions about ultimate outcomes because he must be responsible for the composite end-product of public education. Programmers and programmed learning consultants must focus more attention on this problem in the future. Hopefully, concern about ultimate objectives can be taught. Formal courses in educational philosophy, curriculum development, and learning and personality theory are recommended to accomplish the task. (2) A strong background in research methodology and measurement seems a must for a programmed learning consultant. Evaluation and experimentation have been an integral part of the process of programming from the very beginning. Programming is experimentation, experimental construction of instructional materials. Probably no other educational innovation has from its very inception placed so much stress on evaluation. Programs are built on the basis of how well they meet carefully defined, objective goals. Some kind of objective criterion measure of the performance of students for whom materials are intended is always necessary, even for those who view program writing itself as an art. Problems of sampling, and defining and constructing criteria are crucial, but in addition, new programs are frequently expected to justify their usefulness through experimental evidence demonstrating superiority of programs over other materials or methods. The eventual acceptance of programming by teachers can be enhanced considerably by researchers willing to criticize and continually evaluate their own work. Therefore, even at the master's level courses in tests and measurements, statistics, and research methodology are recommended. (3) Methods used by programming organizations to disseminate and advertise programs must be monitored carefully. The programmed instruction movement is now being scrutinized by a wide variety of potential users, and a most important criterion for the movement's early acceptance will be adherence to a proper code of ethics by professionals who are engaged in dissemination of programs. Ethics should be stressed, especially in internship or practicum experiences, as well as in measurement and specific programming courses for the programmed learning consultant. (4) Orienting teachers to programmed instruction rates high priority, but probably the most important, as well as most difficult, task for programming consultants in the schools is to develop ways to integrate programmed materials with the wide range of existing materials and curricula. Programming skill, technical knowledge, and a great deal of educational know-how will all be needed to meet the challenge. A programmer will have to be particularly skillful in adapting his ideas, methods, and techniques to either new or old personnel and curricula. An internship or practicum is essential for building these skills, and experience in the schools would seem highly desirable.

Programming's rapid growth and increasing influence on education has created the demand for a link between program producers and consumers. In particular, school systems lack consultant personnel who not only understand theories and techniques of programming, but also are competent educators. Now is the time for careful thought to be given the academic training necessary to prepare these personnel. An interdisciplinary course of study for school consultants in programmed instruction has been presented. A strong practicum or internship provides the base for the program which requires at least an exposure to most areas in education and psychology and considerable work in research measurement.

4

PROBLEMS IN THE RELATIONSHIP BETWEEN SUBJECT MATTER AND PROGRAMMED LEARNING SPECIALISTS WITH IMPLICATIONS FOR TRAINING AND RESEARCH

John A. Modrick

John Modrick points out that programmed learning specialists can make a significant contribution by devising a technology which brings together the subject matter and instructional specializations. Subject matter structure and metalanguage are proposed as new tools for use by the instructional programmer to perform his function.

In programmed learning we are confronted with an ancient and persistent problem arising from the condition that teaching requires the mastery of two things: a subject matter and the techniques of communication associated with the transmission of knowledge. The subject matter specialist, be he physicist, sociologist, poet, economist or musician, has content in the form of ideas, principles, and facts which he wishes to transmit to his students. The programmer has principles and techniques for presenting that content in visual, auditory, verbal or performance form. If the instruction is to be effective, the subject matter specialist must ask: "This is what I want to teach; what do you need to know in order to tell me how to present it?" The programmer, in turn, must ask: "What is it you wish to teach so that I can determine the most efficient way to present it?"

The successful management of the interaction between these two specialties or functions is a critical activity in teaching. Programmed instruction can make a major contribution to education by developing a technology for this interaction between subject matter and instructional techniques.

The problem of combining subject matter and instructional methodology is not new. One solution has been to leave both functions with one individual. Thus, the subject matter expert writes textbooks and lectures. All too often the result is books and lectures which, though scholarly, are grossly ineffective for instruction. Another alternative is that the instructional methodologist teaches the subject matter. It has been claimed that this is the direction of modern professional education, and it is further claimed that the outcome of this alternative has been teaching which is a model of technique but ineffective because the teacher did not himself understand what he was trying to communicate or he had nothing to say.

This approach of "two skills in one skull" is not effective. For most people there is not enough time in one life span to acquire and maintain proficiency in a subject matter and in instructional techniques as well. There is also the possibility that the traits which make for excellence in both areas are incompatible or occur together infrequently. The effective, widespread use of programmed instruction will depend on collaboration between subject matter and programmed learning specialists. The programmers will be specialists in instructional methods, program writing, and audio-visual techniques. They will collaborate with subject matter specialists from several disciplines of the arts, sciences, and vocations.

A successful collaboration has existed for years in the construction of achievement tests. Subject matter experts provide the content, that is, identification of the specific knowledges and skills to be tested and the actual writing of items, while the test experts perform the functions of editing and evaluating the items. This collaboration may provide a prototype for the relationship between the programmer and subject matter specialist. However, the model is not adequate for two reasons: (1) the test is much shorter than a program and does not present the same problems of the management of material, and (2) the items in a test are independent of each other; the test builder need not be concerned with the sequence of items. In programmed instruction the sequence of items is the key to the program.

We will have separation of the two functions. Although some specialization on types of subject matter will undoubtedly occur, the typical programmer will have to operate across many subjects. He must be able to communicate with the subject matter specialist for the purpose of obtaining the information necessary to write the specific items of the program and to organize the content of the program in a sequence that will be effective for learning.

There is, then, a third function of communication between the two specialties for the purpose of analyzing the subject matter into a form necessary for program writing. We usually leave the development of proficiency in this communication to trial and error during on-the-job experience. However, we need standardized techniques for this analysis.

To develop these techniques we need two new tools: (1) a set of constructs for describing the conceptual structure of a subject matter, and (2) a metalanguage for talking about subject matters.

Neither of these ideas is yet clear in my own thinking. However, structure of a subject matter is reflected in the fact that a subject cannot be entered at random but there is an order in which the material must be taken. The central ideas in structure are sequence and the condition that some items are prerequisite to others. Some topics and concepts are advanced and sophisticated while others are basic and elementary; some topics and concepts must come first while others are built on, integrate or are extensions of the basic items; some concepts are definitional and existential while others are relational. There are similarities between new and previously mastered concepts which can be used to advantage in presenting new material.

I tend to think of the metalanguage primarily as vocabulary, although I am certain that it includes grammatical rules. As you know, the term is used by logicians to designate a language used to make assertions about another language. We can make the oversimplified distinction that the subject matter is an object language for talking about phenomena in the real world and the metalanguage is a language for talking about the object language.

The first step in inventing the metalanguage would be the development of a taxonomy of concepts and skills. There are two sources of information on which to base the taxonomy. One possible source is the function of a class of concepts in the subject matter. The other source is the psychological characteristics in terms of the cognitive and learning processes of the individual. Whichever source is used to identify classes of concepts, these concept classes are the basic elements of the language to which symbols are assigned. These symbols are the words of the metalanguage. There must be also rules for combining symbols into assertions about the object language. The concept classes are also the things that go into the subject matter structure.

If you find these ideas a little nebulous, I share the experience with you. I cannot give you specific examples of subject matter structures or metalanguages because I do not know of any. However, let me give some examples in an attempt to illustrate what I mean.

The first example comes from my experience as a teacher. In recent years I have taken to asking questions on the assigned materials instead of lecturing at the students. This procedure has been very instructive for me. There are two observations I want to make. One is that the student tends to learn snatches and isolated bits of the material. Although an orderly development and an interdependent sequence of concepts are in the subject matter, the student seldom picks that up readily. What I have to do, as a teacher, is to recapitulate this conceptual organization by a combination of questioning, prompting and interpreting while the student puts in the isolated bits and snatches which he recalls. In this manner, the structure of the subject matter is emphasized.

The second observation is that for more concepts I have to backtrack to more fundamental concepts and ideas and work the student through the development of the concept to be learned. Take the concept of test validity as an example. Although the student can learn the glossary definition, it has little meaning for him. In order to develop the concept of validity, one must build on the ideas of a continum of individual differences, criterion, correlation and prediction of performance from test scores. These concepts are the building blocks of the structure of the concept of test validity. Disregarding this structure produces instructional chaos.

My second example comes from the idea of techniques of evaluating an integral in calculus, at least as I remember learning it. This is not a difficut idea, yet many people have a difficult time mastering it. However, when one looks at the number of concepts and techniques which are prerequisite for learning to evaluate an integral, the concept is truly impressive. Among them are the concepts of function, area, increment, summation, approximation, limit, infinitely small, addition and multiplication. Usually the student is exposed to these concepts at various grades in school. These concepts are the content of the structure of this complex concept. The ease of learning this concept is probably a function of the mastery of these component prerequisite concepts.

My last example deals with electronic maintenance. I had the task of preparing material for a program to be used in research on training. We wanted to teach maintenance procedures on actual military electronic equipment to electronically naive subjects. Therefore, a program had to be worked out by a psychologist who knew very little about the equipment and an engineer who knew the equipment so well that much of his activity had become automatic. We engaged in a lot of groping and trial and error, but after a while it became clear that there was an order and system in what we had to do. For example, we found three major divisions of the material which had to be taken in this order: (1) a limited number of fixed checkout procedures to be learned with normal indications, (2) recognition of negative indications introduced into the checkout procedure, and (3) families of localization procedures associated with each of the negative indications. Further, within these three divisions, it was also possible to identify at each step in the sequence specific knowledges and skills which the student had to master in orderto perform that step. These prerequisite knowledges and skills are then sorted into related groups and taught to the student. Within each of the divisions we found it either necessary or advantageous to take items in a particular order.

As we worked through the subject matter we began to see its organization and structure and to recognize types of concepts. The individuals who did this work will be able to apply the method to other programming tasks, but individuals facing this type of subject matter for the first time will have to repeat the same trial and error. Science and technology cannot be so dependent on individual idiosyncratic skills acquired through experience. We must develop standard procedures and techniques for the analysis of subject matters and this development requires the development of the constructs of structure and metalanguage.

The structure and metalanguage are the tools for analysis of subject matter into the kinds of concepts being taught and the sequencing of this content into an optimum sequence for learning. This is the work of the programmer. Programming is not just the writing of items or frames. The writing of items is important but only part of the job. Programmed instruction is a technology for the transmission of knowledges and skills to the student. The programmer's objective must be to optimize this communication and to do this he must be able to analyze subject matter from a pedagogic point of view.

The basic idea in the structure is that some items of knowledge are prerequisite to the acquisition of other items. There are two ways in which a concept can be prerequisite. One is logical necessity. The other form is prerequisiteness in terms of ease of learning or understanding. There are undoubtedly concepts which can be learned directly but, if these concepts are preceded by certain kinds of learning, they could be learned much more rapidly. We need to identify classes of concepts, study the manner in which each class of concepts is learned, determine techniques to facilitate the learning and apply these techniques to the writing of programs.

One can, of course, point out that programs have been written in the absence of subject matter structure and a metalanguage. However, existing programs are most numerous in subjects having very little structure, such as language, or subjects having a traditional empirically-derived structure, such as mathematics and logic. Languages have virtually no hierarchy of concepts. There are basic categories of vocabulary and rules of grammar which must be mastered, but reaching the intermediate levels of proficiency consist of increasing the number of associations within a category and increased speed of recognition of words and construction in various contents. In mathematics, on the other hand, a definite hierarchy exists in which more complex and difficult concepts are based on simpler concepts learned first. However, the existing structure in mathematics is not necessarily the true structure. This is apparent in the successful attempts of recent years to teach supposedly advanced topics, such as set theory, to high school freshmen. When we have the techniques for analyzing the structure of a subject matter, we may find that there are many pathways through mathematics and we must choose between them in terms of some index of effectiveness.

Research on concept learning has been on a plateau for some time. Most experimental work has been a variant on the early advances of Heidbreder, Hull, and Smoke. However, there are occasional findings that point in the direction of a taxonomy of concepts. The concept classes are usually related to ease of learning. For example, Heidbreder (1946) found that the order of increasing difficulty in learning concepts was concrete objects, spatial forms and abstract numbers.

Kendler and Vineberg (1954) studied the learning of compound concepts formed by combining two lower order concepts. For example, the subject learned a compound concept in which the combined attributes of size and shape of objects both defined the concept. The ease of learning these compound concepts was related to the number of component concepts (0, 1, 2) that had been learned prior to learning the compound concept.

An interesting incidental finding is that one of the concepts was extremely difficult to learn. Four simple concepts were used: shape, size, color, and a fourth called part-whole. Part-whole is a relational concept and it was consistently more difficult to learn. The hypothesized explanation is that there is not a natural, readily available, verbal-mediating response for the part-whole characteristic. There are, however, readily available mediators for the other concept attributes. In almost any subject matter, many of the concepts have no natural, or readily available, verbal mediators to facilitate learning.

A final example is the work of Bruner, Goodnow, and Austin (1956) on conjunctive and disjunctive concepts. A conjunctive concept is one in which both of two characteristics, A and B, must be present; a disjunctive concept is one in which one or the other of two characteristics, A or B, must be present.

Recently Neisser and Weene (1962) reported a study of concept learning in which ten types of concepts were used. The ten concepts included univariate and multivariate concepts representing various types of conjunction and disjunction. The ten types of concepts represented three levels of complexity. The levels of complexity corresponded to the difficulty of learning the concepts and within a level of complexity there were differences in difficulty by type of concept.

My reason for reviewing these studies is that they represent some ways of defining concept classes. The classes are defined by formal abstract and general properties independent of content. Concept classes so defined are related to differences in learning. The next step is to apply these types of analyses to concepts in subject matter. We should then be able to formulate additional rules of programming that will increase the effectiveness of programmed instruction.

My presentation has been almost entirely in terms of knowledge and concepts, while skill has been neglected. This has been largely a convenience in speaking. Skills are another aspect of the taxonomy and structure of a subject matter. My attention has been caught recently by a "Taxonomy of Educational Objectives" by Bloom. In the cognitive domain the objectives include such skills as interpretation, application, judgment and various kinds of analytical skills. This is probably not an adequate taxonomy of skills, but it is a start in the right direction.

In conclusion, I repeat that programmed learning can make its greatest contribution by devising a technology which brings together the subject matter and instructional specializations. This will be done if the programmer sees himself as a subject matter analyst who extracts from the subject matter the information necessary to accomplish the instructional objectives. To perform such an analysis, he will need new tools like the subject matter structure and metalanguage.

IBEX—A METHOD OF INSTRUCTION

Robert Pursley, Major, MSC

Major Robert Pursley is an instructor at the Army's Medical Field Service School. He has the difficult task of teaching relatively dull administrative procedures to relatively disinterested Medical Service Officers. By combining business simulation, role playing and programmed instruction, he presents training that seems to crack the motivation shell and challenge the intellectual abilities of his students.

Glaser (1962) in his introductory comments to his recent book entitled, "Training Research and Education" comments:

> One of the essential obligations of a society at peace is the education of its members. It is also true that an essential mission of a military establishment during peacetime is the training of its personnel.

But, before we can train our military establishment, we must keep its members healthy and able to perform the "vigour" of this training. The prevention and treatment of disease and injury, be it ever so slight, is a 24-hour, 7-day a week business. It is to this purpose, that is, the prevention and treatment of disease and injury of the Army establishment, that the members of the Army Medical Service devote their full-time effort.

The faculty of the Medical Field Service School must train our students. Although we draw completely upon the civilian educational institutions to provide us with the finest physicians, dentists, and veterinarians, the Army must complement their civilian education with the pure military skills which are vital to our defense. Our newly commissioned Medical, Dental, and Veterinary Corps officers must acquire a basic knowledge of military map reading, weapons capabilities, infantry and artillery tactics, and the problems of practicing military medicine under combat conditions. Since these young officers may become the team captains of tomorrow, every effort must be made to develop and enhance their leadership abilities. Further, we must orient this new officer to the administrative processes of the Army establishment. It is to this purpose that I wish to relate a recent experience with programmed instruction.

But first I would like to ask you two questions: (1) How can we make the learning of the "administrative processes" more effective and enjoyable?; and (2) How can one generate an interest of physicians, dentists, and veterinarians along the lines of military letter writing, personnel accounting and reporting procedures, or just the everyday routine variety of "paperwork"?

This is one of our motivational problems. I do not wish to imply that this routine paperwork is either unnecessary or unimportant. On the contrary, good administrative processes are vital to good patient care. The answers to these questions have been the subject of discussion for many hours by the instructors of the Medical Field Service School.

Heretofore, the lecture has been the principal method for presenting these subjects. In an effort to increase the effectiveness of these hours, we have made what we believe to be a unique experiment by combining two relatively new methods with one older method of instruction.

The methods used are: (1) Business simulation, sometimes called gaming; (2) Programmed instruction, primarily branching; and (3) Roleplaying.

First let me describe the business simulation method.

> "A business simulation or game may be defined as a sequential decision-making exercise structured around a model of a business operation, in which participants assume the role of managing the simulated operation." (Greenlaw, 1962)

At the Medical Field Service School we have designed a 2-day classroom "game" which is presently 16 hours in duration. Our classroom "game" has been named IBEX which is an abbreviation for the title In-Basket Exercise. In one sense, this exercise simulates the administration problems which appear in one's in-basket. The 112th General Dispensary located in Garmisch, Germany, has been selected for the exercise model or hypothetical work environment.

The transition from normal classroom lectures to the IBEX method is not sudden. Great effort is taken to set the "mood" wherein the participants can obtain definite facts about their new job. The student officers are slowly pulled into a hypothetical work situation in which they pretend being assigned and performing duty at an overseas general dispensary. They are asked to go by the assumed name of a Medical Corps officer who has just recently arrived in Germany from his orientation course at the Medical Field Service School at Ft. Sam Houston, Texas.

At this point, instruction of the "administrative processes" is begun. The methods used to introduce teaching objectives referred to as "plays" include: (1) Letters, memos; (2) Telephone calls; (3) Roleplayers; and (4) Other.

Fundamental details of a "given subject area" have been programmed to prepare the participant to respond to a "planned roleplaying situation." Remember, at this point the participants have received little or no instruction on the "how to's" of paperwork before reading their programmed pamphlets. Time is allowed in the classroom to read the short branch program before the roleplaying situations are begun. Also, time is allowed for the participants to discuss the newly acquired knowledge with their neighbor. The average reading time for the programs used to date is between 15-20 minutes (small steps).

The programmed instructional material fills the gap between the participant's lack of Army experience on the everyday detailed procedures and his intuitive problem-solving capabilities. In other words, a large volume of standing operating procedures or procedural guides have been greatly reduced to the essentials which enable the student to begin functioning in a work situation.

Upon completion of a short discussion period the instructor names a student to participate in a short skit wherein he must apply his new knowledge to a decision-making situation. Normally, an informed "roleplayer" (usually a faculty member) is used to present the problem to the student participant. Once the participant has made his decision and indicated to the class his action, the skit is stopped by the instructor. The student participant is asked to discuss the good and bad points of his solution to the problem presented. Once the student roleplayer has discussed his own actions, the other members of the class are encouraged to ask questions or make comments.

Almost without exception, each teaching objective is developed without comment by the instructor. This permits the instructor to actually observe the success or failure (terminal behavior) of the teaching objectives of the student participant and his fellow students asking him the questions.

Let me discuss the advantages of this method as we see them: (1) Variety; (2) Active participants (not passive listeners); (3) Immediate feedback; (4) Primary roleplayers are peers; (5) Forces the instructor to prepare clearly defined teaching objectives; and (6) Teaching objectives are developed by fellow students.

The following are the disadvantages: (1) Time consuming; (2) Requires a great amount of preparation time; (3) Instructors must be thoroughly trained; and (4) Minor changes require complete rewrites.

In conclusion, I would like to summarize the findings obtained from a short questionnaire which was designed to measure the student's attitude or reaction to our first exercise. We used a 2-page questionnaire with completion type items. Some sample questions were: (1) How do you feel about IBEX in general? (2) How do you feel about the subject material presented in IBEX? (3) To what degree did IBEX create a better learning situation than lectures?

Generally, all participants indicated that the exercise was very effective as a training method. Most students indicated that the subjects were essential and the method of presentation made "what could be dull material interesting." All indicated that they believed the exercise was more effective than the lecture method.

A specific question was included to determine which method used in IBEX was most meaningful from the student's point of view. The question was: "From which of the following methods used in IBEX did you learn most: (1) Programmed instruction; (2) Roleplaying; (3) Committee discussions; (4) Referring to general reference material; (5) Telephone calls; and (6) Written communications?" Results were: 51% indicated roleplaying; 38% indicated programmed instruction; and 11% indicated all others.

The comments made by the students were most encouraging. For example: "More such type instruction should be instituted." "The most enjoyable and interesting instruction for a subject which is extremely uninteresting to an individual who has spent so much time in classes during the last 28 years." "If possible, I would suggest even more student participation. If one knows he might be called upon, he will more likely endeavor to understand the material." "Use programmed instruction more. To me, this is the most beneficial part of IBEX."

From our first exercise, we feel that combining simulation, programmed instruction, and roleplaying provides another very useful instructional method. Further, it is my personal conviction that programmed instruction can be a very effective method in generating interest of professional groups such as physicians, dentists, and veterinarians in purely administrative subjects.

NOVELTY EFFECTS OF PROGRAMMED INSTRUCTION

W. James Popham

W. James Popham investigated the possibility that the effects produced by machine presented programmed instruction are due in part to the novelty of the teaching situation. He matched two groups of sixth grade, half of whom worked with teaching machines for a fall semester. In the spring, both groups learned the same new material by machine. Both groups showed equivalent gains in knowledge, suggesting that novelty effects, if present, were not sufficient to produce differences.

"How much of the apparent success of teaching machine learning is merely due to the 'novelty effect' produced by the devices?" Particularly in the case of teaching machines, in contrast with programmed books, one might suspect that the very uniqueness of the devices themselves could produce heightened student motivation and hence superior learning. While programmed texts are in many respects more comparable to conventional instructional materials, even the effectiveness of these materials may be underestimated because of their novel features.

This question mirrors a concern of educational researchers as well as school administrators who might consider possible acquisition of self-instruction equipment. To the researcher, the question dictates caution in the interpretation of what generally have been rather encouraging experiments testing the effectiveness of programmed learning approaches. To the school administrator, the question may engender enough skepticism to discourage the use of self-instruction devices, even on a trial basis.

Only Porter (1958) reports research bearing on this important question. He offers evidence that after a five month period of using teaching machines there was no indication of lessening student motivation. More recently, both Keislar (1959) and Carr (1960) have warned against the possible influence of novelty effect, an effect which might lose its value over an extended period of time. In commenting on the Porter research, Carr urges that ". . . more research of this sort (dealing with novelty effect) is necessary before we can be sure that confirmation can be relied upon to maintain its reinforcing property for very long periods of time."

If the foregoing observations are accurate, it becomes apparent that attention should be given to the possible influence of novelty effect upon learning acquired through approaches featuring auto-instructional devices. The experiment to be described was explicitly designed to explore this question.

The experiment proposed to supply evidence relevant to the question of how much influence, if any, a postulated novelty effect would have upon the effectiveness of learning in a self-instructional situation. Specifically, the null hypothesis tested was the following: There will be no significant difference in the achievement of two comparable groups of elementary pupils in a self-instruction learning situation when one of the groups uses teaching machines for the first time and the other group has had extended previous experience with the machines.

Essentially, the research design of the project involved comparisons of the performances of two student groups on an identical self-instruction learning task. It was postulated that a novelty effect which might be conducive to better learning was present to a greater extent in the case of the students who were learning via machines for the first time.

In greater detail, one group of sixth grade elementary school pupils (hereafter referred to as the low novelty effect group) had a semester's experience with a teaching machine approach to learning the fundamentals of algebra. During the 1961-62 fall semester, each student devoted three 30-minute periods a week to an algebra program presented by a Foringer #2002 teaching machine. The machine instruction took place in a vacant classroom, adjacent to the regular classroom, under the supervision of a student assistant. During this period the second group (hereafter referred to as the *high novelty effect group*) had no contact with the teaching machines, but was introduced to comparable algebra topics by the regular classroom teacher.

During the spring semester both groups devoted three 30-minute periods per week to an elementary geometry program, also presented by the Foringer devices. Students in the high and low novelty effect groups were randomly assigned in equal proportions to four teaching machine work groups who used the six available teaching machines at different times. It was assumed that the greater familiarity of the low novelty effect group with the machines and general procedures associated with self-instruction would tend to mitigate that interest in the geometry materials which might be attributable to the newness of the instructional approach itself. Whereas, with the high novelty effect group, using the teaching machines for the first time, the uniqueness and hence inherently interesting nature of the situation would be apparent.

Subjects in the two groups were drawn from a single sixth grade class in the Frederic Burk School, the San Francisco State College elementary demonstration school. The two groups were matched at the beginning of the school year according to pupils' scores on the *California Test of Mental Maturity and SRA Arithmetic Achievement Test.* Recent scores on both these measures were available for all students from school records. Twelve students formed the high novelty effect group, while eleven students were included in the low novelty effect group.

The criterion measures by which the null hypothesis was tested were students' difference or "gain" scores between an initial geometry test, administered at the beginning of the spring semester, and two other geometry tests administered later during the spring semester. All items for these tests were drawn from the suggested tests accompanying the TEMAC programmed geometry learning materials.

The first test, a 40-item instrument, was administered to all subjects during the first week of February. This test, which covered frames 1-200 of the self-instruction program, was used to assess the knowledge of geometry that students possessed prior to their use of the machine-presented geometry programs. It should be noted that the performance of the two groups on the February test was quite similar. For the high novelty effect group the mean number right was 6.75 and the standard deviation was 3.54. For the low novelty effect group the mean number right was 7.00 and the standard deviation was 2.28.

All students initiated their work on the geometry programs on February 13. On March 6, a 63-item geometry test covering frames 1-600 of the program was administered to both groups. At that time nine half-hour work sessions had been made available to each student so that, barring absence, each student had devoted 270 minutes to the machine-presented geometry materials. Difference scores of the two groups were contrasted by the nonparametric Mann-Whitney *U* Test. Differences between the groups with respect to (1) number of frames completed and (2) time devoted to the programs were also checked.

In the original design of the experiment the March 6 test, administered relatively soon after students had initiated their work on the geometry programs, was considered important because a possible influence attributable to novelty effect might be present during the early stages of the two groups' use of the geometry programs. It was considered possible that such an early novelty effect influence might be dissipated as the experiment wore on, hence the early testing. If a significant performance difference favoring the high novelty effect group had been observed during the March 6 testing, it was planned to administer periodic achievement tests to both groups after every nine or ten teaching machine work sessions in order to note the continued presence or disappearance of this performance differential.

As will be seen in the results section of this report, periodic testing was not dictated by the results of the analysis of the March 6 test data, hence only a final criterion examination was administered at the close of the spring semester on June 4. This terminal examination consisted of 116 items with 145 possible points for a perfect paper. The test covered frames 1-1850 in the geometry program. Difference scores of the two groups were contrasted by the Mann-Whitney *U* Test. Differences between the two groups were also noted with respect to number of frames completed as well as number of sessions devoted to the teaching machines.

Also on June 4 a questionnaire designed to assess student attitudes toward the teaching machine mode of instruction was administered to both groups. Differences between questionnaire responses of the two groups were tested for statistical significance by the nonparametric Fisher exact probability test.

Before turning to the performance of the two groups on the criterion tests, it will be useful to examine the comparability of the students on the measures of intelligence and arithmetic achievement used to match the two groups. In Table I the means and standard deviations for both groups on these two measures are presented.

Analysis of March 6 results. Prior to analyzing test results of the two groups after the March 6 testing, differences were appraised between the groups regarding time expended on the teaching machines as well as number of frames completed.

Because of the possibility of student absences resulting in less machine time for one group, the minutes

Table I

Performance of the High Novelty Effect Group and Low Novelty Effect Group on the California Test of Mental Maturity and the SRA Arithmetic Achievement Examination

		California Test of Mental Maturity		*SRA Arithmetic Achievement*	
Group	n	$\overline{X}$	s	$\overline{X}$	s
High Novelty Effect	12	68.58	7.95	57.33	12.41
Low Novelty Effect	11	68.64	7.20	57.18	11.27

devoted by each student to the programmed materials were recorded. Time devoted to the programmed learning by each group was quite similar, with mean minutes of machine time for the high novelty effect group equalling 242.5, and for the low novelty effect group 233.0. The number of frames completed by each group was almost identical ($\overline{X}_{hne} = 256.16$; $\overline{X}_{lne} = 261.40$).

The mean of the two groups' "gain" scores were practically equivalent. The mean of the high novelty effect group was 21.00 while the mean of the low novelty effect group was 21.80. The difference between the two groups, as indicated by a Mann-Whitney test, was not statistically significant ($U = 55.5$).

Analysis of June 4 results. Since the March 6 test revealed no superiority for the high novelty effect group, the terminal examination administered on June 4 was the only other criterion measure employed.

The analysis pattern was similar to that employed for March 6 data. First, differences between the two groups with respect to time devoted to the program and number of frames completed were inspected. As in the March analysis, the differences between the groups on both of these scores were trivial. The mean number of half-hour work sessions with the machines by the high novelty effect group was 33.92. For the low novelty effect group the mean number of sessions with the machines was 32.18. The mean number of frames completed by the high novelty effect group was 998.8, while for the low novelty effect the mean number of frames completed was 1,026.5.

The mean performance of the two groups in terms of "gain" scores was quite similar. The mean of the high novelty effect group was 41.42 and the mean of the low novelty effect group was 39.73. The difference between the two groups, when analyzed by a Mann-Whitney test, was not statistically significant ($U = 62.5$).

On the basis of data analysis for both criterion tests, then, there were no significant differences between the two groups. Hence, the null hypothesis under investigation was considered tenable.

Results of the three geometry quizzes administered in February, March, and June are reported for the high novelty effect and low novelty effect groups in Table II.

Analysis of questionnaire results. Both groups completed a questionnaire at the close of the experiment which solicited student opinions regarding the teaching machine mode of instruction. In an effort to induce greater validity in the responses of the students, the questionnaire directions implied that responses to the instrument would be forwarded to each pupil's new junior high school in the fall, where they might play a role in determining whether the student would use teaching machines in the future. Students were asked (1) Whether they liked to use teaching machines; (2) Whether they would prefer to study mathematics by teaching machines next year; (3) Whether they felt the teaching machines were used too often in class; (4) Whether they would have gotten more or less out of the course if the teaching machines had not been used; (5) Whether they became tired of using the machines as the school year progressed; and (6) Whether they would choose to use teaching machines for part of their study in their next school.

Responses of the two groups to all of these questions were almost identical. The lack of a statistically significant difference was verified by computing six Fisher exact probability tests.

Consideration of the results of this experiment leads to the conclusion that insofar as novelty effect was produced (for both groups) and diminished (for the

Table II

Performance of Twelve High Novelty Effect Pupils and Eleven* Low Novelty Effect Pupils on Three Geometry Examinations

	February Test 40 items		*March Test 63 items*		*February-March "Gain"*		*June Test 116 items*		*February-June "Gain"*	
Group	$\overline{X}$	*s*	$\overline{X}$	*s*	$\overline{X}$	*s*	$\overline{X}$	*s*	$\overline{X}$	*s*
High Novelty Effect	6.75	3.54	27.75	10.37	21.00	9.04	48.17	23.25	41.42	27.78
Low Novelty Effect	7.00	2.28	28.80	9.01	21.80	8.86	45.82	19.26	38.82	18.60

* One low novelty effect student was absent during the March testing.

low novelty effect group) by the design of the study, it was not a factor of importance in the self-instruction learning task. The null hypothesis was accepted on the basis of the criterion test administered in March, a few weeks after the high novelty effect group started to use the teaching machines. The null hypothesis was also accepted on the basis of the criterion test administered four months after the high novelty effect group initiated their teaching machine work.

It should be pointed out that the "gain" scores used to test the null hypothesis do not actually represent advancement on the same test, for on each testing occasion a geometry examination was devised which would cover only that portion of the program which might reasonably have been encountered by the students in the experiment. Thus, a longer test was used for the March testing than had been used in February, and a still longer test was used in June.

A comment should also be made regarding the reason for the selection of algebra and geometry materials for use with sixth grade pupils. These programs were chosen since it was assumed that pupils' knowledge of both subject matter areas would be relatively minimal. The geometry program was selected to follow the algebra program used by the low novelty effect group since, although it contains concepts and skills which are different from those encountered in algebra, it falls in the same overall content field of mathematics. It was believed that if a program from a totally different field (such as a foreign language) had been chosen for the second semester, the low novelty effect group might have viewed the new learning materials as being sufficiently novel to cancel out the novelty effect differential the study was designed to produce.

It should also be noted that since the experiment was conducted in a college demonstration school where college student-observers in classrooms are fairly common, the possible influence of "hawthorne" effect was probably diminished. On the other hand, this same situation might make it more difficult to generate a novelty effect for sixth grade youngsters who have experienced several years of adult observation.

Finally, it must be emphasized that while the results of this study will be viewed with favor by those proponents of programmed instruction who believe the merits of this approach to be based on sound learning principles rather than novelty effect, the results of a single study are far from conclusive. We must await results of further experimentation before the novelty effect variable can be excluded from our considerations in programmed learning research.

The performance of two groups of sixth grade youngsters on an identical teaching machine learning task was contrasted in this experiment. One group of pupils had been exposed to a teaching machine learning task for a semester, the other group used teaching machines for the first time. It was postulated that "novelty effect" would be present to a greater degree in the case of those youngsters in the latter group. On the basis of two criterion tests, one administered early in the experiment and one administered several months later, no difference between the two groups was discovered. Novelty effect was concluded to be of no importance in the learning situation.

A POTPOURRI OF PROGRAMMING TECHNOLOGY

James L. Evans

James Evans presents some new ways to prompt the behavior of a programmer as well as a student. The programmer can prompt his production of frame materials by one of two permutation techniques. A modified binary flow chart, developed to organize Latin translation functioned as a very effective prompt when given to students using the final program. By using appropriate directions, students can be prompted into making organized, permanent notes of programmed materials. Finally, a tail-first vanishing technique is reported that teaches simple cartooning.

The programming enterprise is a serious effort to apply behavioral science to the process of human learning. An easily overlooked fact is that the programmer himself is a behaving organism, and is subject to the same laws of behavior which he is utilizing in his programming technology. As my colleagues and I have attempted to apply behavioral principles both to our students and to ourselves in practical programming situations, a number of techniques and by-products have emerged. My paper is a sample of some of these by-products.

In programming, we attempt to arrange a series of stimuli which insure that the student will proceed rapidly and effectively to mastery performance. We acknowledge the fact that the behavior of the student is controlled by the stimuli we present him. Can we then deny that our own behavior in programming is largely controlled by the stimuli impinging upon us? Let me quote from a description of how one scientist took self-prompting seriously.

> "He took 63 cards and placed on them the names and properties of the elements. These cards he pinned on the wall of his laboratory. Then he carefully re-examined the data. He sorted out the similar elements and pinned their cards together again on the walls. A striking relationship was thus made clear. He now arranged the elements in seven groups. . . . He continued to arrange the remainder of the elements. When his list was completed, he noticed a most remarkable order. How beautifully the elements fitted into their places!"

The scientist in question was, of course, Mendeleeff, and the result of his self-prompting was the discovery of the Periodic Law of Chemistry (Jaffe, 1956). If Mendeleeff was wise enough to take self-prompting seriously, can we who are in the business of producing and controlling verbal behavior afford to take it less systematically? I think not. In 1959, Lloyd Homme, Robert Glaser, and I described a "verbal matrix" technique for use in the generation of programs. Further analyses have led us to the conclusions that the two-dimensional matrix therein described is but a special case of a very powerful and general method of using permutational techniques in generating, prompting, and analyzing verbal behavior.

Let me relate an incident which may clarify my previous remarks. In reviewing a rather bad program on Metric Measurement which turned up on my desk one day, I was struck by a singular fact. Apparently the programmer was attempting to establish certain relationships within and between certain classes of terms which appeared in the program, and he was approaching this in a quite unsystematic and ineffective manner. I then began examining each frame of the program to find a term which might represent a member of a larger set. For example, the term "meter stick" is obviously a member of the set of measuring instruments, and I immediately examined the remainder of the program to see what other measuring instruments were mentioned. Interestingly enough, at no point in the program was mention made of instruments for measuring time, although time measurements are fundamental to any measuring system.

Figure I represents my expanded analysis of the topic, which I have chosen to call the "set-permutational" technique. Several properties of the classes themselves are of interest. In some cases, the members of the set are ordered, for example; there is an obvious ordering of metric prefixes. With respect to measuring instruments, however, no such ordering is apparent. There are some varieties of relationships both within sets and between sets. For example, in the metric prefixes there are a number of relationships, based on factors of ten, to be learned relating prefixes such as pico-, nano-, micro-, and so on. Also, within classes, there are relationships between basic units such as feet and seconds, and derivatives such as feet-per-second squared, or acceleration. There are also one-to-one, one-to-many, many-to-one, and many-to-many relationships between classes. For example, the metric prefixes permute completely with metric suffixes. That is, if you select eleven metric prefixes and five metric suffixes, you can generate 55 metric units, such as milliseconds, kilograms, megaliters and so on. Examples of one-to-one set relations are between metric suffixes and English units. The student who masters the program might be expected to convert from inches to meters, liters to quarts, and so on. The fact that length measurements can range all the way from picometers to gigometers also is a powerful prompt to the programmer to point out that different measuring instruments are appropriate, depending on the level of measurement. For example, a micrometer would be used for making measurements in millimeters, whereas a meter stick might be more appropriate in making measurements in decameters. The point is not that the programmers must incorporate all these relationships in his program. What is important, however, is that through permuting within and between the various classes, the programmer at least prompts himself to consider all of the logical possibilities, and he can select examples systematically without a resulting loss in generality.

After the members of two or more sets have been generated, the problem still remains of some systematic method of generating all the logical possibilities resulting from permuting the sets. In general, two somewhat different techniques have proved useful in exhausting the logical possibilities resulting from the permutation of two or more sets. Suppose the programmer has generated a set of subjects, a set of verbs, and a set of direct objects for use in generating examples in a language program. In particular, suppose the set of subjects contains two members (numbered 0 and 1), the set of verbs contains five members (0 through 4), and the set of direct objects contains three members (0 through 2). The more general, and more mundane, permutational procedure is to use the odometer technique. Using this technique, the programmer will proceed from 000 to 001, 002, then advance to 010, 011, 012, and so on. In this case, the programmer will generate all logically possible example sentences before they are exhausted and he begins recycling. An alternate procedure can be used when the numbers in each set are all relatively prime to each other. In our example, since 2, 5, and 3 are all relatively prime, the second or relative prime technique can be used. It should be noted that by the insertion of one or more dummy or blank cards to a given set, the set can usually be made relatively prime quite easily. When the dummy or blank cards come up, that combination is simply ignored. As an example, in conjunction with generating all logically possible three-letter words of the consonant-vowel-consonant pattern for use in a reading program, we had 21 consonants for the first position, five vowels for the second position, and 21 consonants for the third position. By adding one blank to one of the piles of 21, we increased its number to 22, which is relatively prime both to 5 and to 21. To use the relative prime method of permuting classes, simply transfer a card from the top to the bottom of each set, and then record or use the resulting permutation. As long as the sets are relatively prime pair-wise, all logical possibilities will be generated automatically, with no duplications until the possibilities have been exhausted and the combinations begin recycling. I have an idiosyncratic preference for the relative prime technique, if for no other reason than that it seems to move faster and does have the desirable feature of providing a premixed set of permutations for use as examples.

It might be noted in passing that the use of such systematic techniques in example generation in programs can be an effective control device over the behavior of the programmer. In analyzing a rough draft of our Spanish program, we found quite disproportionate utilization of certain nouns, verbs, and adjectives, although in programming, we had attempted to provide equal practice on vocabulary items. In a Ger-

A SET PERMUTATIONAL ANALYSIS OF METRIC MEASUREMENT

English Units	*Metric Prefixes*	*Metric Suffixes*	*Property Measured*	*Measuring Instrument*
poundal	pico-	gram	mass	stop-watch
inch	nano-	second	length	micrometer
second	micro-	•	time	meter-stick
•	milli-	•	•	•
•	•	•	•	•
•	•	liter	•	•
horsepower	•		volume	chemical balance
feet/sec	kilo-		acceleration	
feet/sec^2	mego-			
	•			
	•			
	•			
	giga-			

Figure 1

man program we are now revising, the relative prime technique will be used to assure much more homogeneous practice on individual vocabulary items.

In summary, then, as an analytical tool, key terms or concepts in a subject matter area can be identified, the set to which they belong also identified, and additional members or sets generated as necessary. The pair-wise permutation of these sets can prompt the programmer both in the analysis of the subject matter and in the generation of examples. Both an odometer and a relative prime technique have been described for exhausting the possibilities of the permutation of two or more sets.

The set permutational technique previously described has proved to be an extremely useful self-control and prompting device on certain phases of programming. Unfortunately, however, permutations per se do not necessarily result in the ordering or sequencing necessary in arranging the series of stimulus events which constitute a program. As I have described in a previous paper (Evans, 1961) sequences or chains of behavior, particularly when expressed in a notational system borrowed freely from computer programming, can be powerful analytic devices and may show interesting insomorphic relationships even between diverse subject matter areas. Behavioral analysis using flow chart notation proved to be such a powerful analytical tool that we, of course, behaved as any teacher or priest possessed of new knowledge would; that is, we kept the flow charts carefully concealed from our students. When someone outside our programming ranks asked the obvious question. "Why don't you let the student see your flow chart?" we became rather ruefully aware that we were on the student's side and there was no reason why the student should not see the flow charts. By using the program to control the student's use of the flow chart, we discovered a number of interesting points. First, we were sometimes able to achieve a saving of 50 percent or more in the number of frames needed to produce criterion behavior. Second, since the flow charts essentially mediated between the initial stimulus and the terminal response, they started dropping out of the student's chain of responses, as any operant conditioner who has ever worked with behavioral chains in animals would confidently predict.

Figure 2 shows an experimental flow chart used in teaching Latin translations. We have data from a cumulative record of a student translating a series of Latin sentences of a particular pattern into English, using the flow chart. The data indicate that the initial latencies in completing the translation of each sentence are relatively long, with successively less time being used in translation, culminating in a steady rate of translation. In the construction of a Bridge program in which flow charts for opening bids, responses, opening leads, and so on, are freely used, it is a routine observation that the use of the flow chart "drops out" or "short circuits" to the point that the student is no longer dependent upon them. As Tom Gilbert (1962) would point out, the dropping out of such mediators is to be expected in the attempts of the organism to economize his efforts in reducing the delay of terminal reinforcement.

In both our own testing laboratory and field testing situations, we had often observed students taking notes in either more or less organized fashion, and we had often heard the requests of students for advice on what sort of note-taking procedure to follow. Again, the hangover from conventional instruction was so potent that we kept forgetting that we were on the student's side. Eventually, it dawned upon us that there was no reason why we could not control the student's note-taking process with a "programmed notebook" with the same precision with which we controlled his learning with programmed instruction. That is, we would make up the "ideal" notebook in advance, and then so structure the programmed instruction phase that the student would gradually complete the notebook in a pre-determined order. In this way, we were sure that the student ended up with a comprehensive and carefully organized set of notes, in contra-distinction to the often erratic notes taken by most students.

Figure 3 will give you an idea of how the programmed notebook works. After testing a program in Matter and Chemical Change, we gave 12 students an attitude questionnaire which included, among other things, a question on their attitude toward the programmed notebook. The students did report the usefulness of the programmed notebook in preparing for a retention test.

The last ingredient of our potpourri belongs in the "For What It's Worth Department." A much neglected area in the field of programmed learning is that of programming the learning of skills such as sketching, drawing, or cartooning. I would like to offer for your attention a device which, through the straight-forward application of behavioral principles, has produced surprisingly good results in teaching even young children to produce cartoon figures. The production of a cartoon figure by an artist is a clear-cut example of a behavioral chain. To teach an artist to run off the same behavioral chain, the principle of chaining dictates that the novice should first provide that detail of the drawing which the cartoonist provides last. This procedure, of course, runs contrary to the well-established procedure in which the student is instructed,

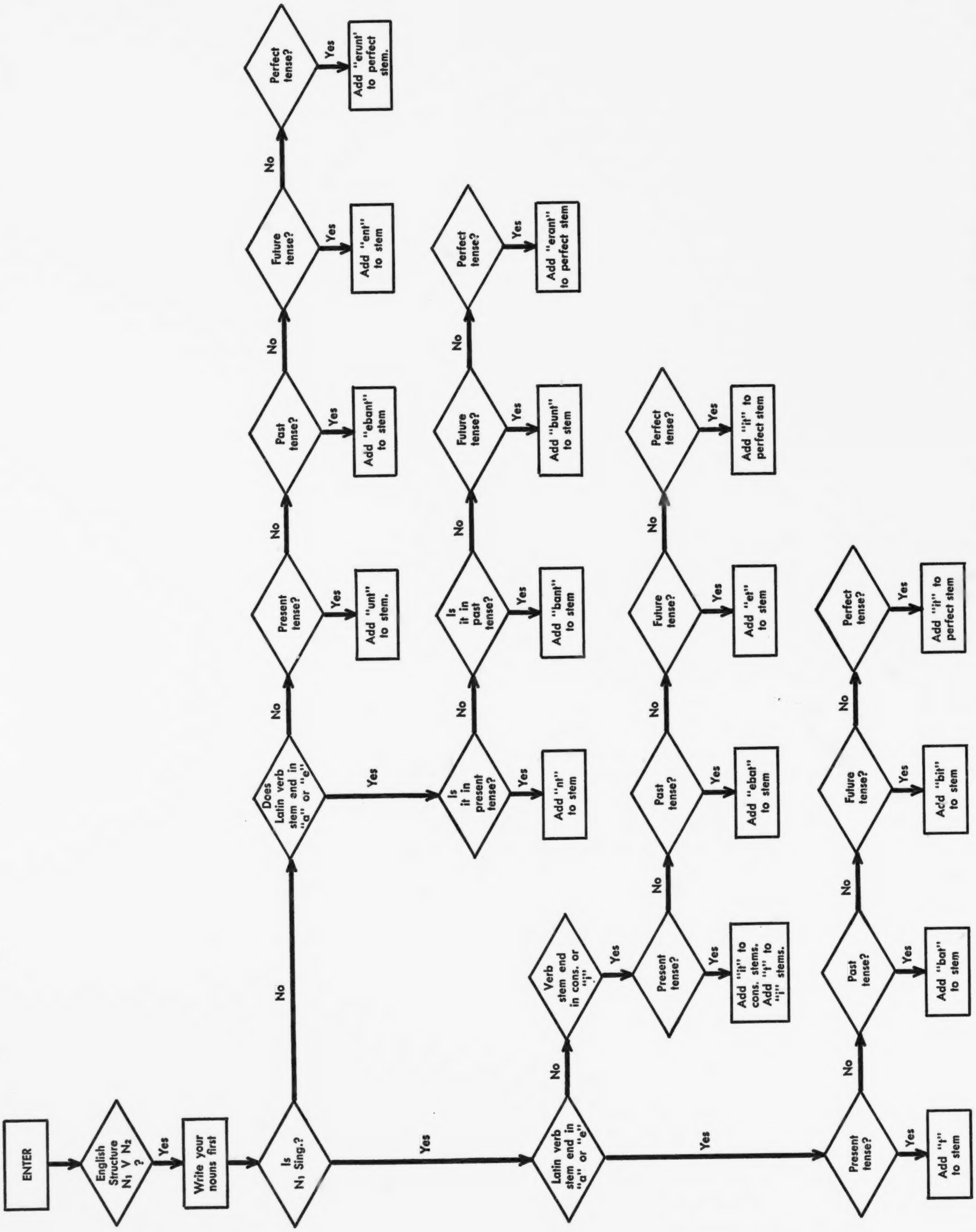
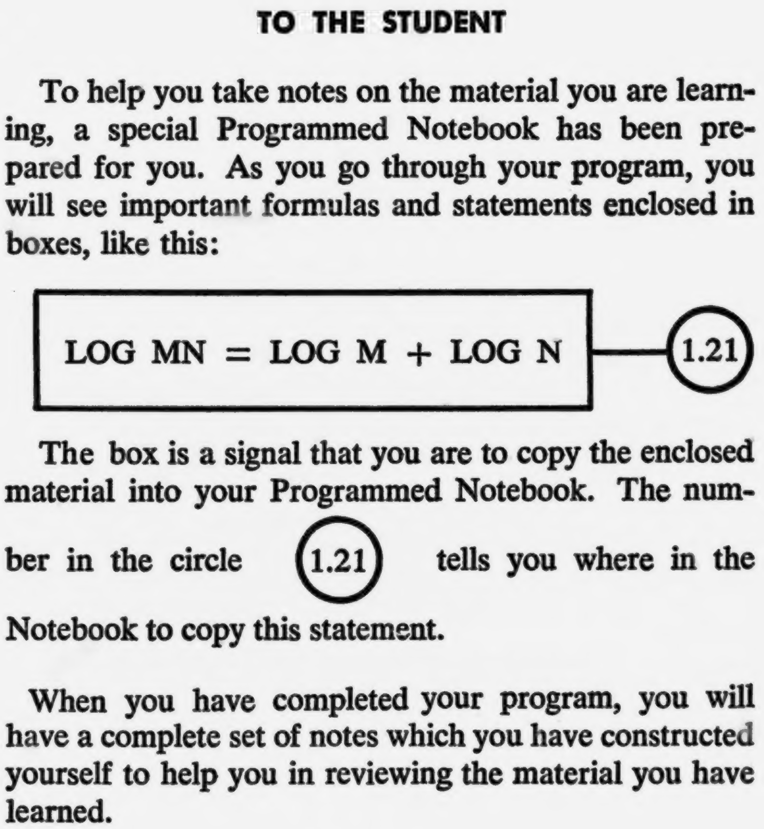

ENTER
English Structure N₁ V N₂ ?
Yes
Write your nouns first
Is N₁ Sing.?
No
Does Latin verb stem end in "a" or "e"
No
Present tense?
Yes
Add "unt" to stem.
No
Past tense?
Yes
Add "ebant" to stem
No
Future tense?
Yes
Add "ent" to stem
No
Perfect tense?
Yes
Add "erunt" to perfect stem.
Yes
Is it in present tense?
Yes
Add "nt" to stem
No
Is it in past tense?
Yes
Add "bant" to stem
No
Future tense?
Yes
Add "bunt" to stem
No
Perfect tense?
Yes
Add "erant" to perfect stem
Yes
Latin verb stem end in "a" or "e"
No
Verb stem end in cons. or "i"
Yes
Present tense?
Yes
Add "it" to cons. stems. Add "t" to "i" stems.
No
Past tense?
Yes
Add "ebat" to stem
No
Future tense?
Yes
Add "et" to stem
No
Perfect tense?
Yes
Add "it" to perfect stem
Yes
Present tense?
Yes
Add "t" to stem
No
Past tense?
Yes
Add "bat" to stem
No
Future tense?
Yes
Add "bit" to stem
No
Perfect tense?
Yes
Add "it" to perfect stem

Figure 2



TO THE STUDENT

To help you take notes on the material you are learning, a special Programmed Notebook has been prepared for you. As you go through your program, you will see important formulas and statements enclosed in boxes, like this:

$\boxed{\text{LOG MN} = \text{LOG M} + \text{LOG N}}$ — (1.21)

The box is a signal that you are to copy the enclosed material into your Programmed Notebook. The number in the circle (1.21) tells you where in the Notebook to copy this statement.

When you have completed your program, you will have a complete set of notes which you have constructed yourself to help you in reviewing the material you have learned.

Figure 3

"If you're going to draw a bunny rabbit, first draw two circles like this." The device consists of a number of acetate sheets bound together in book fashion. When the book is closed, the student sees the complete cartoon figure. The student is given a Magic Marker and instructions to "trace what is in red on each page, and then complete the rest of the drawing." On the second sheet, the cartoon figure is again complete, but the tail, which is the last detail of the drawing chain, is in red. By using a different color to control the student's tracing behavior, we can force the observing response to that portion of the figure that is going to be removed in the next step. This technique arose when early tests indicated that students were not reliably identifying which links of the chain were being successively removed. However, by instructions to "trace what is in red and then complete the drawing", we found that the observing response necessary for the completion of the chain can be easily controlled. At the second step, the student would trace the tail, and again would have a complete dog before him. He then turns the page, and now the tail has disappeared completely, and the nose is in red, indicating that the student should trace the nose and then add the tail to complete the drawing again. On the next step, the details of one eye are traced, and then the student adds the nose and the tail. On the next step, the student traces the details of one eye, adds the details of the other eye, the nose, and the tail. Successive steps fade away the feet so that the student provides, in turn, feet, eyes, nose, and tail. Ear and head details are then faded away, with the student running off the complete chain in each case. In the next to the last step, the student traces the outline of the body, and then runs off a very well-established chain which completes the bunny. The final step in the program is simply a blank sheet of acetate, and the student produces the complete cartoon figure without prompting. The slight discrepancies between the final production and the original model are known as artistic creativity. Informal observation indicates that the younger the organism, the better he chains. Young children run through the chaining sequence beautifully; sophisticated adults, however, have learned that you begin things at the beginning and are prone to attach the tail first, or to violate the law of chaining in other ways.

A minor technical note in the construction of this cartoon chaining device is that the artist starts at the back of the booklet and works on the backside of the acetate. Since the student proceeds through the chaining sequence from the front, his marks are on the opposite side of the acetate from those of the artist. The student's drawings, therefore, can be wiped clean so that the program can be reused.

In this paper, I have attempted to present some technological by-products which my colleagues and I have found useful in producing programs and in attempting to make programs more effective. I hope that one or more of the techniques which I have presented will be of use to you in your own programming activity. In summary, if a potpourri can be summarized, we are finding that the programs we are now writing and the techniques which we are now using don't look very much like the programs and techniques we were writing and using five years ago, three years ago, or even six months ago. This is as it should be. This is only an indication that we are still on the threshold in learning to apply the principles of behavior to the learning process.

X Evaluations

JUDGING THE TEACHING EFFECTIVENESS OF PROGRAMS

Henry C. Ellis

Internal and external characteristics by which the effectiveness of a program can be judged are contrasted. Prediction of a student performance criterion based on internal characteristics of a program is not very reliable. Reliance should be placed more on such external measures as: final achievement, crude gain, residual gain and ratio of gain to total possible gain.

A relatively convenient way to judge the teaching effectiveness of programs is to begin by distinguishing between *internal* and *external* characteristics of a program. This distinction has been proposed by Joint Committee on Programmed Instruction and Teaching Machines (1963) and appeared in their interim report of 1962. Internal characteristics of a program refer to features which can be judged by visual inspection of the program, whereas external characteristics refer to features which are revealed by the performance of students after completion of a program or are revealed by relatively "objective" features such as data on tryouts and revisions, sources of program content, qualifications of authors, etc. This paper will deal primarily with external characteristics, and in particular with problems associated with obtaining and assessing data indicating gain in achievement produced by the use of a program.

At the present stage of programming technology, it seems desirable to rely somewhat more on external rather than internal characteristics of a program in judging its teaching effectiveness. It is not an easy task to judge the effectiveness of a program by mere inspection of it since the viewer may not be entirely sure about those features which he should examine. In addition, not enough evidence is known about programming technology to permit one to rely entirely on internal characteristics, nor can we predict with certainty that a program which has certain specified internal characteristics will necessarily be a program which reflects large gains in achievement. For example, a program may have frequent review, appropriate stimulus control, proper sequencing, and yet show very little evidence for gain in learning. Similarly, it is possible that a program will appear to have face validity and again show little evidence for gain in learning. Finally, it should be stressed that no attempt is being made to diminish the importance of internal characteristics but only to call attention to their limitations. Future research in programming technology may reveal those internal characteristics which correlate highly with whatever is desired of a program. Meanwhile, external characteristics appear more useful as criteria for judging programs.

Two external characteristics useful in evaluating the teaching effectiveness of programs will be examined: measures of gain in achievement, and evaluation of the program by students, teachers and subject-matter-experts. This is not an exhaustive list of external characteristics; however, these two characteristics are perhaps those most important in judging *teaching* effectiveness of programs.

The most fundamental kind of data which reflects the teaching effectiveness of programs is some measure of gain in achievement. "Does the program actually teach what it says it teaches?" is a basic question which the potential buyer wants answered. Regardless of all the niceties of a program, if it fails to teach it is useless, and if it teaches and is accurate in its content, it is an extremely useful program. There are several types of measures that one may employ in measuring achievement. First, one may employ some measure of *final status* in achievement following completion of a program. Second, one may employ *crude gain,* which is simply the algebraic difference between a pre-test of achievement and a post-test of achievement. Third, measures of *residual gain* may be determined. Finally, one may employ a measure which is the *ratio of crude gain to total possible gain.* Each measure has certain properties which will be examined in more detail.

Final Status Measures. Measures of final status indicate achievement following the completion of a program. An obvious limitation of final status as a measure of achievement is apparent in that although the achievement may be relatively high, the measure does not directly reflect how much achievement is associated with the program *per se.* Final status measures are useful for assessing relative level of achievement but they do not reflect that portion of learning which can be readily attributed to the use of the program.

Crude Gain. Crude gain is a superior criterion of learning for the purpose of evaluating teaching effectiveness of programs. If no other instruction is given during the pre-post test interval, it is fairly reasonable to attribute gains in achievement to the program itself.

Except under highly controlled experimental conditions, the program is likely to be used in conjunction with on-going classroom instructional activities which may parallel and duplicate the content and objectives of a program. Under these circumstances, gain in achievement will reflect both the effectiveness of the program and the effectiveness of classroom instruction and it will be difficult, if not impossible, to attribute such gain to either type of instruction or to know what weights to attach to either. If one is to use gain scores as indicators of the teaching effectiveness of programs, then the program, ideally, should be used in the absence of additional instruction which is similar to that provided by the program. That the latter circumstance may be unlikely suggests clear-cut limitations of the gain score.

Although I have argued elsewhere (Ellis, 1962) that the gain score appears to be the most useful in evaluating the teaching effectiveness of programs, it has obvious limitations. The fact that greater gain is achieved with one program as compared with another *may* simply mean that the former program was administered under conditions where extensive classroom instruction of similar content and objectives were given.

This limitation of the gain score may lead some to conclude that comparative studies provide an answer. Comparative studies are those in which some experimental group, which receives a program, is pitted against a control group, which does not receive a program, but does receive "conventional" instruction. A number of researchers (Ellis, 1962; Holland, 1961; Stolurow, 1962) have pointed out the limitations of the comparative or control *vs.* experimental study. Yet, recently the Technical Committee of the NSPI (1962) proposed, in a checklist for selecting programs, that the program be evaluated against alternate methods of instruction. I have previously described the difficulties associated with the comparative study (Ellis, 1962) and have described its "non-analytic" character.

Residual Gain. A second limitation of the gain score has been described by DuBois and Manning (1957). They point out that gain measures are composed of two uncorrelated parts, that part which is uncorrelated with initial status and that part which is perfectly predicted by initial status. Since gain is a composite measure, they conclude that a measure of learning which is independent of initial status would be superior to that of gain which is confounded by what the learner already brings to the situation. As a solution, they propose that *residual gain* be employed, since this provides a measure which is independent of initial individual differences in learning. Following their line of reasoning, it would appear that crude gain, as a measure of the teaching effectiveness of a program, has an obvious limitation—that of being a composite measure which reflects not only the effect of some treatment variable, but also the initial status of the learner. Although this is a valid criticism of the gain measure as an appropriate dependent variable in studies of learning, it does not appear to be a sufficiently serious critique to warrant abandoning this measure entirely in studies of programmed instruction. One may still evaluate the teaching effectiveness of a program using gain providing one takes into account this feature of the gain measure.

Gain/Total Possible Gain. Another way of measuring gain in achievement associated with the use of programmed instruction is to compute the ratio of gain actually achieved as compared with total possible gain. The obvious advantage of this measure is that it provides a way of estimating the efficiency of learning by controlling for differences in the initial status of learning. For example, if the pre-test measurement of achievement is high, then there is little room for possible gain in achievement. Gain scores may be misrepresentative and may appear unusually small because of high initial scores. The ratio of gain to total possible gain, however, takes into account how much can be learned from the program and provides an objective index of the program's efficiency.

The second external characteristic which is useful in measuring the teaching effectiveness of programs consists of evaluation of the program by students, teachers, and subject-matter-experts. Although data on gain in achievement is extremely valuable, educators have the ultimate decision of judging whether the program is congruent with their own educational objectives. At GPTC we have had the experience of seeing a program lauded by one school system because it provided the kinds of skills necessary for students, whereas the same program has been rejected or ignored by another school system because the program did not fit in with the latter's objectives. In both instances, objective data on achievement was essentially the same. Although a program may show considerable gain in achievement, the educator still has to answer the question, "Is this desirable or worthwhile for my students to learn?" Thus it seems quite clear that considerable responsibility is placed on educators or other potential users of programs to determine if the program contributes to their own needs and objectives in education. The impact of programmed instruction is to require greater not less effort and responsibility on the part of the user of programs.

Teacher Evaluation. The teacher must answer at least two fundamental questions in order to judge the effectiveness of a program: "Do students learn?" and "Does the program contribute to my instructional objectives?" The first question is relatively easy to answer;

at least it poses fewer problems than does the second question. An answer to the second question requires that the teacher have a rather clear conception of his educational objectives. Where the teacher is not clear as to his own objectives, he will experience difficulty in judging whether a program contributes to his professional task.

Student Evaluation. It is important that student response to a program be positive. Fortunately, it is unlikely that students will enjoy a program if they fail to demonstrate at least acceptable amounts of learning. Preliminary findings from field-testing of programs at Roanoke, Va., indicate that student evaluation of programs is positively correlated with the amount of learning which occurs. Obtaining student evaluations of programs is relatively simple as several questionnaires are readily available for the potential user of programs.

Subject-Matter-Expert Evaluation. Finally, the effectiveness of programs can be judged by subject-matter-experts. The subject-matter-expert can best judge the adequacy and correctness of the content as distinguished from whether or not students will learn from the program. It is important that the user of programs have assurance that the program was developed with the assistance of a subject-matter-expert prior to the publication of the program.

This paper has described two general ways of evaluating the teaching effectiveness of programs: measures of achievement gains and evaluation of the program by students, teachers and subject-matter-experts. Advantages and limitations associated with various types of gain measures were described. Finally, the necessity of obtaining evaluations in addition to learning measures was emphasized.

VALIDATION DATA FOR PROGRAMMED TEXTS: A CHECKLIST FOR EVALUATION OF TESTING

Hannelore Vanderschmidt

Hannelore Vanderschmidt points out that with programmed texts, the burden of student performance is shifted from the student or teacher to the program and its publisher. The author then lists and analyzes eight criteria by which both publisher and potential user may evaluate the quality of programmed texts and suggests that it is the responsibility of publishers to conduct and publish such test information.

When Harold Sands of the American Institute for Research recently addressed a group of Boston publishers, he suggested that publishers would have to assume a much greater degree of responsibility for programmed texts than they have for traditional texts. If students do not learn from an ordinary text, some of the onus could always be shifted to the teacher or to the student's performance. With programmed instruction the burden of student performance falls squarely on the program and, by reflection, on the publisher.

The publisher can make sure that the program works by conducting a thorough field test or having such a test conducted by the author or by a professional testing group. If the publisher prints a validation statement, including test results, with the program he does a service for all of its potential users. By printing the validation the publisher also does himself a service. For instance, if Mrs. Jones comes to him with the sad story that the modern arithmetic program did not work with Harold, aged 7, the publisher can point to the printed validation data which states that the program was meant for students with a 6th grade reading level and that it assumed certain arithmetic skills as prerequisite knowledge.

In general, a validation statement traces the history of the program through its research, development and field test stages and it defines the program's educational intent, indicating with what group and under what conditions the program has been shown to work.

In order to guide our own company with the testing and validating of programs, I examined 40 commerically published programs. These were published by 15 different book companies and programming firms. Of the 40 programs examined, 25 presented no validation information at all. Only one program contained a validation which leaves no pertinent questions unanswered. I rated the validation information in the programs according to a list of 8 criteria of my own devising. These are:

1. A statement of prerequisite knowledge.
2. A statement of terminal objectives.
3. A pre-test and a post-test with analysis of pre-post test data.
4. A description of the test population.
5. A statement of error rate.
6. Suggestions for program administration.
7. A statement of average time required to complete the program.
8. A measurement of student attitude.

Naturally, the 8 criteria are not of equal importance. Those criteria which assess how well the program fulfills its stated claims, 1-4, are, in my opinion, more important than the other criteria. On this scale the mean rating for validations in the test group of programs was 1.4 with the "validated" programs taken by themselves scoring 3.5. These figures are self-evident. The American program publishers today are not printing complete validation statements.

The Field Test

Since validation information inevitably harkens back to program testing procedures, a good validation necessarily requires a carefully constructed field test. Such a field test typically includes a pre-test which is used to select the experimental population, the administration of the program to the experimental group, a post-test to assess whether the program meets it stated objectives and, finally, an evaluation of the test results.

A fairly simple test such as the following will exemplify these points. In an arithmetic program for grade 1 which I wrote under the guidance of Douglas Porter at Harvard University in 1961, we assumed that the student could form the numbers 1-10 and could match the numbers with the corresponding number of objects. Our pre-test of 30 items included 6 items to assess whether the student mastered this prerequisite knowledge; the remaining 24 items tested his knowledge of the terminal objectives. Students were selected for the experiment if they answered the prerequisite questions correctly, but did not answer most of the objective questions correctly. Age and I.Q. variables were also taken into consideration. The program was administered and subsequently a post-test, which was identical to the pre-test. Student gains from pre-test to post-test were assessed by simple statistical techniques.

Prerequisite Knowledge

To design a field test the experimenter must be able to list prerequisites and terminal objectives. Why should this material be included in the validation? The potential user must know what knowledge is assumed by the program to be able to determine whether or not his own students have the prerequisite knowledge. If not, he can bring the students to the necessary base line. None of the programs I examined included a list of prerequisites, although one did specify the reading level required. I think that a statement of reading level is particularly valuable to the user as most programs today rely very heavily on the reading knowledge of the student.

I am well aware of the difficulties of spelling out the prerequisite knowledge. Over-specificity needs to be avoided as much as the vague amorphous answer. I would hope to see a statement of prerequisite knowledge less vague than "all that has gone before" or "for the 8th grade level," but, at the same time, more easily read than a list of 100 technical terms and 300 concepts, each of which should be mastered by the student.

Terminal Objectives

Tests included in a program are often good measures of its terminal objectives. Of the programs examined, 8 contained tests: "diagnostic tests," "unit tests," "mastery tests," or "pre-post tests." By scrutinizing the tests included in a particular program, a teacher or other potential user can gain a fair understanding of its terminal objectives. The table of contents of many programs also gives some indication of their objectives.

A more formal way of specifying terminal objectives is to list these in operational terms. By this I mean that the program lists operations the student can perform on completion of the program: he can spell the following list of words, he can define the following terms, and so on. The use of operational terms circumvents vague descriptive statements such as "he appreciates," "he understands" or "he knows." As John Blyth has pointed out in his excellent article, "Behaviorism Is Not Enough," (1962) there are some human activities which cannot be specified in behavioral terms. Still, the operational attempt to translate the learning activity into a group of measurable skills makes those skills readily accessible to testing. To return to programmed instruction, unless we can test to see if a given terminal objective is actually in the student's repertoire at the completion of a program, we have little assurance that the program has fulfilled this objective.

Pre-Post Tests and Pre-Post Test Data

Pre-post tests should be published with the program, not only because of their usefulness as an indicator of terminal objectives, but also because by including them, one gives the potential user a way to evaluate their construction and to see whether they constitute a fair measure of the program, if he is knowledgeable. Tests are useful for the teacher's use in ascertaining how well his particular students are learning. None of the programs I looked at included an analysis of pre-post test data. I was surprised to find this because how well the students do in the post-test (if it is carefully constructed) is an excellent indication of how well the program works. By comparing the pre-post test performance of the experimental group or groups you can determine how extensively and with what groups a program works. I do not advocate statistical raptures. These serve to offend the expert and cause the mathematical layman to flee. But, I would like to see some evidence that the test administrator, be he author, editor or testing expert, tried to ascertain how well the program meets its objectives.

I have heard that "you can prove anything with statistics" over and over again. I know it is fairly easy to "rig" the test and the test results. Still, most educators will try to write valid and reliable tests and to evaluate them honestly.

Test Population

All of the 15 validated programs in the test group contained information about the test population such as age, grade level, I.Q., where the tests took place and how many individuals were involved. Age and I.Q. variables are particiularly important, I believe, because they set certain necessary restrictions on the use of the program.

Error Rate

The question of error rate has dogged programmed instruction since Skinner suggested that it be kept below 10%. Since then, it has been noted that the student could miss all the criterion frames and still have a very low rate if the program included a large percentage of extraneous responses or responses which were extraneously cued. Of course, what the student misses is more important than how much he misses. Yet, information about the error rate, how it varies from bright to slow populations, what has been done to decrease it, is pertinent. If nothing else, it attests to the care that has gone into developing the program.

Program Administration

Suggestions for program administration are very useful to the teacher, especially if he is among the large group who has not used programmed instruction before. Susan M. Markle's Teacher's Manual for the program, WORDS, contains much information which would be useful to a teacher. She discusses branching and double tracking sequence for different ability groups. She suggests whether and how students should use these sequences, whether students should be kept together, and so forth. I think many programs would be more effectively used if the author-programmer would follow this example and suggest administration procedures.

Time Requirements

This information, available from the field test, should be included in a validation to help teachers make time allotment decisions.

Student Attitude

Although I have not read any studies offering conclusive proof that a positive correlation of student attitude and student achievement exists in programmed instruction (1963), I am convinced from experience that attitude is a factor in student success. At any rate it is a factor in determining whether or not a student completes a program. He can hardly be expected to learn what it purports to teach if he finds it too dull or too punishing to complete.

Because of these considerations some measure of student attitude is valuable. The results of a sophisticatedly conceived attitudinal questionnaire or, in the case of an "optional" program, some measure of the number of students who finished the program as compared to the number who started it would give the would-be-user an indication of how successful the program was in motivating its students.

Two publishers have gone on record to say that each of their programs will be field-tested and that printed validations will accompany each program. Theoretical considerations for testing and validating programs are at this time being studied by a distinguished group of scholars working for the Educational Testing Service. These efforts are much to be lauded and will, I hope, yield a crop of first-class programs. Nonetheless, the major effort in assuring quality control of programs must come from each programmer and each program publisher. Only by producing programs of high quality can we make certain that programmed instruction will assume a significant role in American education.

REAPPRAISAL OF ACHIEVEMENT MEASURES

Michael A. Zaccaria and John Olsen, Captain, USAF

Michael A. Zaccaria and John Olsen define present concepts of aptitude and achievement reliability and validity and then analyze the merits of test item difficulty discrimination developed for aptitude tests but misapplied in achievement testing. The authors conclude that achievement tests must measure students against performance standards and not compare students relatively among themselves.

In government and industrial technical training today we hear a great deal about minimum training to meet minimum job requirements. Training managers seem to agree that money and manpower are wasted by over or under training. They go to great lengths in developing curriculum to fit this training philosophy.

Unfortunately, once training gets under way we often find that the philosophy of minimum training in minimum time gets lost in measurement policies which are based on traditional academic considerations. Too often students are measured to fractions of a percentage point against other students without ever being measured against minimum job requirements. There are two main reasons for this phenomenon. First training objectives are seldom stated in definitive enough terms and secondly, a relative rather than an absolute measurement system is employed.

To fully understand this complex problem it is necessary to contrast aptitude and achievement testing with regard to validity and reliability. It is also necessary to understand item difficulty and item validity as applied in technical training. The following terms then will be discussed to show the contrast between academic and training definitions.

Validity. How well does the test measure that for which it was intended? In aptitude testing validity is used to predict how well individuals will succeed in training. Thus, the concept of *predictive validity.* In achievement testing validity is used to determine how well the student has achieved the goals of the course, thus the concept of *content validity.*

Normal Curve. In aptitude testing we wish to show a maximum of individual differences. Thus, we like to have a normal curve with a maximum spread of scores. By use of such a device it is fairly easy to select individuals for course attendance.

How is a normal curve attained? By using a maximum number of test questions which half of the examinees answer correctly. This includes a small proportion of very easy questions and a small proportion of very difficult questions.

Item Validity. There are two types of test validity; internal validity and external validity. Internal validity has to do with consistence of items with the total test score. For example, suppose we have scores on a test ranging from 50 to 100. Arbitrarily divide the higher scoring papers at 90 and better and the lower scoring papers at 60 and poorer. If 70% of high scoring individuals and 20% of low scoring individuals got question one correct, then this item is consistent with the total score. If these proportions were reversed, this question would be adversely selective of "good students" or "high aptitudes." In aptitude testing all questions should be positively selective and all adversely selective questions must be discarded from the test. This should not be the case in achivement testing for a number of obvious reasons.

In a training situation the ideal is for every student to get zero on each question of the pre-test before training, and for each student to answer every question correctly on the post-test. This would yield a range of 0 and a mean of 100. We should not be teaching students things that they already know and we *should* attempt to teach all students everything they should know. If this ideal training goal were completely reached, we would not have a normal curve of achievement scores. We would have everyone scoring 100% on the final examination. Consider the problems this would cause for the training administrator or academician.

External item validity is a good concept for both aptitude and achievement tests, under certain conditions. The problem of using an external criteria, such as job success, for achievement test items is that there are too many factors other than job competence that determine supervisor ratings of job success. In a recent study, for example, it was found that supervisors gave graduates high performance scores on tasks which the graduates had never performed. Individual personality of graduate and supervisor, work conditions, and dozens of other uncontrolled variables make up what is referred to as "job success." There are some goals we can foresee and can test, but this does not satisfy us. We want a normal grade spread.

If all students answer a question correctly under existing systems that question gets thrown out, or it is made harder by making it trickier. This should not be the case. If, for example, everyone completing basic training should know that in event of capture in time of war he should only give his name, rank, serial number, and date of birth, then this should be a test item.

If 100% of students answer this question correctly, then we have accomplished this objective. Removing this question from the test is ridiculous. The achievement test should measure how well we have achieved our training objectives. If such a question is removed from the test, we will not know if students in subsequent classes have learned this objective. If the instructor knows students in past classes have achieved so well on this item that they are no longer tested on it, he may feel it is unnecessary to even discuss the subject in class.

There is no reason why we should insist on having a normal distribution of scores in our achievement tests. And yet, this is what we get when we discard questions that all students answer correctly. Thus, we do not test on objectives that instructors have been completely successful in teaching. On the other hand, if the instructors do a poor job of teaching the material, the question is also discarded because it does not help us put scores into a normal distribution. In short, these practices do not improve the training situation.

The normal curve that we get from our present test validation procedures does not help us to evaluate and improve our training. It only enables us to tell which are our best students and our worst students, and to more or less rank-order them. We then count on normal ability to adjust to work conditions. Our procedures do insure a higher relationship between aptitude and achievement. Of course, this is built in so that our achievement tests tend to become measures of aptitude rather than achievement. As a result of present procedures, it is very difficult to find out whether or not our training goals have been achieved. Without this determination there is little chance of improving training programs.

Item Difficulty. Items that are of moderate difficulty, those that 50% of the examinees answer correctly, are those that maximize individual differences. Test questions that are either too easy or too difficult will not help give us a normal distribution curve of total scores.

When a test is to be used for selection purposes, it is important that there is somewhat of a normal distribution curve.

In aptitude testing, it is perfectly legitimate to make easy questions more difficult and difficult questions easier. Thus, the end result is a maximum of moderately difficult questions, and a small number of easier and harder questions. This will help obtain a normal distribution if that is the desired result of the measurement program.

Reliability. Reliability of tests can be divided into three areas for the purpose of this discussion:

a. Equivalence of two tests

b. Stability of the same test given at two different times

c. Homogeneity or sameness throughout or within a given test

In aptitude testing, all of the above criteria should be met. That is, if two forms of a test are to be used, they should be equivalent. The score of an individual should be the same whether he takes Form A or Form B of the test. If an individual does not receive essentially the same score today and a month from now on the same test, it is of little use for predictive purposes. In aptitude testing, it is legitimate to throw questions out of a test because they do not contribute to the total score for that test.

For achievement testing, under present measurement philosophy, test reliability is only important from the standpoint of equivalence of two or more forms of a test (except when a course is used as a selection tool). All forms of a particular achievement measure must be equivalent in that an individual should be equally successful regardless of which form of the test is administered.

In summarizing the differences outlined in the above definitions it is fair to say that much of the item analysis procedure that is now in use is worse than useless for achievement testing in technical and military training courses. This type of procedure precludes the measuring of objective achievement and improving training. Training managers should not require the use of item difficulty and item validity (of the internal consistence type) as criteria for discarding or retaining test questions in achievement tests.

We in training and perhaps in education should be working toward tests that tell us (and the students) how much has been achieved during a class or course and not merely how the students rank with one another. If a solution to this problem cannot be found, we can just as well give grades based on shoe or hat size and forget the measurement mumbo jumbo we now use.

XI Future Trends

PROGRAMMING THINKING

Francis A. Cartier

Francis Cartier points out that a number of aspects of rational thinking (e.g., formal logic) can be taught by present programming techniques. Formal logic accounts for only a small part of the rational and creative processes we call thinking. An experimental program on recognition of fallacious reasoning has been partly successful and is now being revised. Many other behavioral manifestations of rational and creative thinking can be programmed, such as the principle of deferred judgment, the habit of considering many alternative solutions, discrimination skills, etc. There is reason to believe that programmed instruction need not be based solely on an operant-conditioning philosophy of the human mind. All the principles of programming, except those of the overt response and immediate reinforcement, could be applied within a phenomenological frame of reference, or within a motivational, gestaltist, or even existentialist frame of reference. Perhaps the future of programming theory will include workable hypotheses which recognize the validity of subjective experience, indeterminacy, and even the inherent ambiguity and covertness of certain mental processes.

One absolutely sure-fire method of starting an argument is to raise the subject of teaching students to think with a program. Some of the stricter behaviorists refuse to even discuss the subject of thinking. They will only discuss observable behavior and will have nothing to do with such ambiguous and covert processes as thinking. So they are likely to reject the idea that you can teach thinking with programming.

Oddly enough, the critics of programming take a similar position. One of the most common complaints we hear from teachers, who hold to traditional methods of instruction, is that programming cannot teach thinking, and especially that it cannot teach creative thinking.

I'd like to take issue with both groups. I'd like to report on an experiment in teaching reasoning with a linear program; discuss some thoughts on programming creative thinking; and finally, make some rather broad, tentative generalizations about the applicability of programming theory to mental processes. My sole purpose in all this is to provide some thinking about programming thinking.

We can begin by disposing of one of the simpler questions: can programming teach formal logic? The answer is certainly, "Yes." As formal logic is usually taught, it consists of a very explicit set of rules, very much like algebra. Indeed, formal logic is often reduced to an algebraic (e.g., Boolean) notation system, and programs already exist for teaching certain aspects of symbolic logic. The most avid critic of programming would have to admit that, to this extent anyway, you can program what he would willingly agree to call a thinking process.

But, with rare exceptions, formal logic is useful only to determine the validity of certain kinds of arguments, *ex post facto*. As Chester Barnard says in *The Functions of the Executive,* logic is what the executive uses to justify the decisions he has already made.

Few people would claim that formal logic accounts for all the higher mental activities. Indeed, it has only very little to do with our most important reasoning processes. Nevertheless, formal logic describes at least one aspect of thinking, and we know it can be programmed.

Let us turn our attention to another aspect. Most books on effective thinking devote a chapter or two to fallacies of reasoning. Some of these are logical fallacies, sometimes called formal fallacies, in which the rules of formal logic are violated. But others are outside the realm of formal logic, as in the use of name-calling to refute a point, or the common trick of attempting to divert the argument by accusing an accuser of a similar transgression. Can programmed instruction be used to teach students to recognize these kinds of false arguments? Would we call this thinking?

Take the second question first. Suppose we ask a student to read an argument that he has never seen before. Suppose we then ask the student whether the reasoning in that paragraph is sound or fallacious and he can tell us. Wouldn't you admit, in order to do that, the student would have to think? Most people would. But suppose further, if he says it is fallacious, we then require him to tell us what specific kind of fallacy the paragraph contains. Is there anyone who will deny that a student would have to think in order to give the correct answer? Let me give you an example of what I mean. Here is Frame 126 from a linear program on recognition of fallacious reasoning.

> "Why go to college? Do you expect to make a lot of money as a result? Education is no use to you unless you learn how to use it. Four years of business experience is better than four years of isolation from the real world."
> This is an example of ____________.

The student **must decide** whether to write in the words "sound reasoning", or to identify the nature of the fallacy. Notice that this is not a matter of formal logic. There is no syllogism here. Nor are there any direct conclusions drawn. Nor can you deny the truth of any of the statements. Yet, it seems to be an argument against going to college, and was almost certainly intended to sound that way. It is a "ghost" argument.

Altogether, the experimental program we developed at Headquarters Air Force ROTC takes up twelve varieties of fallacy, using a total of 162 frames. It takes about two hours for a college junior to go through it, with an average error rate of 5%, and a reasonably good score on the criterion test. Of sixteen criterion items at the end of the program, items without confirmations, four out of 21 subjects got perfect scores, and 12 out of 21 missed two or less. The mean was 12.8 out of 16, and the median was above 14. These are obviously not the scores of a highly successful program, but I take them as evidence that the program is teaching something, so I am still working on it.

You may be interested in the way the program is developed. After a few introductory frames, the student is taught to recognize the first kind of fallacy, the fallacy called the "complex question." This takes twelve frames. After that, the program begins to teach the second type of fallacy, the "argument ad hominem." This takes eight frames. At the end of that sequence, the student is taught to expect an example of either the first or second type. Three or four frames are used here to be certain he differentiates between them. Then the program proceeds with a series of frames on the "ghost argument." After that sequence, the student encounters a few frames which review the three kinds of fallacies he has learned. Each example is new. With a few rare exceptions in which we take two or three frames to examine a particular example, every paragraph the student is asked to evaluate is different. We are not teaching him to recognize particular fallacies, but to recognize the pattern of thinking that produces each kind of fallacy. For example, frame 77 reads:

> "There are good books and bad books. The good ones should be required reading, The bad ones should be burned."
> This is a *____________.

And frame 78 reads:

> "The Air Force is concerned with aerospace warfare. The Army is concerned with ground warfare," is an example of a *____________.

The response in both cases is, "false dichotomy." As the program proceeds, the examples become more difficult and require much more sophisticated evaluation processes. Frame 109:

> "Don't tell me that flourine cannot harm you, even in one part to a million of drinking water. Everyone knows it is poisonous. If it is a poison in large quantities, if cannot be healthy for you just because it is taken in small quantities."
> This is an example of *____________.

Beginning with frame 98, the student is cautioned that there will occasionally be a frame in which the reasoning is quite valid. Thus, from that point on, he must always consider the possibility that there is no fallacy in the frame. These frames were perhaps the most difficult to write. I'm happy to say, however, that a student occasionally misses one of them. I take this to mean that these frames without fallacies are not too obvious.

Like most neophyte programmers, we made some sophomoric mistakes at first, but we learned some very significant lessons from them. Sometimes this seems to be the only way to learn certain things, reinforcement theory notwithstanding.

The mistake we made was to construct our first criterion test for this program in the form of a political speech containing a great many fallacies of reasoning. We asked the test subjects to identify the line number in which they found a fallacy and identify its type. They couldn't do it. *Of course they couldn't!* We hadn't taught them to *find* fallacies, but only to identify them in single paragraphs. So, the next step is to prepare additional frames which will develop this particular skill. Once they know what they are looking for, we shall teach them to *find* fallacies in mock campaign speeches, court testimonies, editorials, letters to the editor, etc.

After that, or perhaps at the same time, we shall probably have to spend some classroom time in oral exercises in which the instructor will read a speech, or the students will listen to a tape-recorded argument, and, hopefully, establish some transfer of training to the listening situation. There is some possibility that this activity might be programmable, too. We hope to get around to trying it eventually.

From there, it will presumably be desirable to devise activities in which the students listen to actual radio or television speeches or debates in real time, read their daily papers, and so on, and search out valid and invalid reasoning from what we might call "the real world."

But will we actually be teaching *thinking?* Well, even though we can show that students do poorly on these items before taking the program, and do fairly well at them afterward, we should be careful about saying whether the program is actually *teaching* them to think. Perhaps all we are accomplishing is *getting* them to think. Perhaps all the program does is get them to read more carefully than before, so they perceive what a paragraph actually says instead of what it seems to say. Whatever it is the students are doing, they do it better after the program. And it is *thinking* according to every definition of the term I know of.

Now let us shift our attention to another aspect of thinking. The Air Force ROTC has been teaching something called Creative Problem Solving since 1953. The design for these lessons, the methods of teaching, and so on, have been my responsibility since about 1956, so the teaching of creative thinking is a matter of considerable interest to me. I have studied and taught it for some time now and am pretty much convinced that you cannot program creative thinking. You can't program it, in my opinion, because there isn't any such thing. There is only *thinking*. But real thinking is so rare, that when we see an instance of it, we feel we need to celebrate the occasion with the use of a special adjective. That's a greatly oversimplified statement of my view, but it will do for the moment.

Now, obviously, if you want to program something according to the principles of operant conditioning, that something must take the form of behavior. You cannot reinforce a thought, because you don't know what it is. Only when the student provides you with some behavioral clue as to the nature of his thought, can you apply the techniques of operant conditioning. Usually, that behavior takes the form of a written word of some kind.

Teaching creative thinking seems to require that we elicit *unique* responses, *unusual* responses. What we want to reinforce cannot be stated in advance as a specific behavioral goal because what we want to reinforce is the unexpected, the invention. This is a terribly complex problem if you fail to think creatively about it yourself. Once you free yourself from preconceptions and biases, however, it doesn't look quite so formidable. For one thing, in the early stages of a creative thinking program, we ought to be satisfied to reinforce any behavior that even comes close to being creative. We can use the principle of successive approximation in several ways here.

For example, one of the kinds of behavior that seems to promote creative problem solving is the consideration of a large number of alternative solutions, instead of considering only one or two. This kind of behavior can be defined and recognized and therefore it can be programmed.

Even more rudimentary to good creative problem solving is the habit of gathering as much information as possible about the nature of the problem before attempting to solve it. This seems very obvious, but it is not instinctive or automatic and must be learned. This habit of restricting the temptation to seek solutions until the problem is well understood manifests itself as a distinctive kind of behavior, which can be programmed.

Another behavioral manifestation of creative thought can be seen in the ability to perceive fine distinctions among things that are similar but not identical, and another is the tendency to make these fine discriminations when analyzing a problem. We know we can program the ability to make some very subtle discriminations because—to cite only one example—David Klaus has done it with the program in art appreciation.

There are other approximative behaviors we can program using techniques now in the programmers' repertoire. A lot can be done in that direction. But we cannot ignore the ultimate problem of reinforcing the truly inventive response. How do we do that? At the present state of the art, I suspect we may have to use a live teacher who can decide in each case what to reinforce and what not to reinforce. I have no statistics on it, but I can tell you about my subjective experience in teaching classes in creative thinking. I believe it can be demonstrated that the instructor's reinforcement of creative or semi-creative responses in these classes tends to increase both the quality and the quantity of creative responses. For such an important objective as creative thinking, we should be willing to go to the expense of hiring creative teachers to do this job. Perhaps, by using programs to teach the more prosaic subjects, teachers will have time to do this important task. We may have to use highly inefficient, subjective, old-fashioned ways of teaching teachers to do this, but that doesn't worry me much. It has been done in the past and can be done in the future.

In fact, I'd like to suggest that some of the most important aspects of creative thinking are necessarily subjective and cannot be effectively approached with a behavioral philosophy of learning.

There has been a lot of research recently into the psychology of creativity, and it is very confusing. Most of it is inconclusive and even contradictory. The number of definitions alone staggers the imagination. But if you take the trouble to examine it closely, I think you may agree with me that the research fails to prove conclusively that there are any identifiable characteristics or traits that are possessed by the people we call creative, and that the rest of us lack. On the contrary, the evidence seems to indicate that these so-called perceptive, creative people lack certain characteristics and traits that can be found in comparatively imperceptive, uncreative people. To put it very simply, most of us are crippled by various mental disabilities and blocks that prevent us from achieving the clear, uninhibited type of thinking that earns the complimentary adjective "creative."

So perhaps the best approach to eliciting so-called "creative" thought from a student consists in applying techniques which will free him from hindrances to normal, healthy thinking, rather than providing him with some new and unusual way of thinking.

Obviously, this hypothesis, for I do not pretend that it is anything more than that, puts one in the business of clinical psychology, or at least on its borders. And this is a business in which behavioral psychology has been of relatively little help, so far. I don't mean to imply that reinforcement theory is never used in the clinic. I have successfully used reinforcement techniques myself working with functional articulatory disorders in the speech clinic. But these techniques don't help us much with the client who is disturbed. The learning laboratories haven't elucidated that subject much, probably because pigeons don't get the kind of emotional disorders that human beings are heir to. Fortunately, however, there is nothing that chains either the clinician or the teacher to behaviorism. As teachers, we are perfectly free to go to phenomenological theories, gestalt theories, social psychology theories, and even to psycho-analytic theories if they can offer anything to help. The big question is, then, can you go that far away from behavioral psychology and still use programming to achieve your objectives? Well, we don't know for certain, but there is no reason to suppose we can't. Actually, the most important aspects of programming as an instructional philosophy are *not* irrevocably bound into the strait-jacket of reinforcement theory. Indeed, if you read up on some of the recent experiments on programming, you will find that the cornerstones of reinforcement theory are being seriously undermined by the research results. It has been shown repeatedly that programs can teach just as well without requiring an overt, relevant response. Several studies indicate that a program can teach just as well without the constant confirmation of correct responses.

Apparently, the really important things that make programming successful have nothing to do with the two assumptions that comprise the very foundation of behavioristic reinforcement theory; the necessity for eliciting an overt behavioral response, and immediate reinforcement. This suggests very strongly that we may be able to expand our horizons beyond a philosophy that equates human thinking with the behavioral responses of rats and pigeons. That we might, for example, consider the application of the most important principles of programming within a transactional psychology or a motivational psychology, or any other, or others, we prefer.

We must still insist on clear statements of objectives, but perhaps they need not conform to the rigid requirements of a behavioral definition. The clinician's objectives, for example, can rarely be stated in terms of specific desired behaviors. We must still insist on careful definition of the status quo of the student at the beginning of the program, but this might be based on diagnostic procedures which use the judgment, and the often largely emphatic perceptive skills, of the experienced clinician, rather than on a cold inventory of isolated segments of behavior. We must still apply the principle of proceeding in the smallest necessary increments as shown by actual tests. We can still apply the principle of ruthless elimination of the irrelevant, and so on. But, the application of these principles is not limited to an operant-conditioning frame of reference; they could be used in a manner consistent with even an existential psychology such as Kierkegaard's. (He was, after all, a great admirer of the Socratic dialogue.)

What would such a non-behavioral program look like? I suspect it would look very much like an ordinary book, but it would be markedly different. It would be written with meticulous attention to the learning process and would exemplify every principle of programming except that it would not necessarily require an overt response and constant reinforcement. There will be those who will say that it could not therefore be called a program, but I don't see why not, nor do I much care what it is called anyway.

The behaviorists deserve our congratulations and our humble and heartfelt gratitude for their monumental contribution in bringing programming into being. But there are those of us who find a strictly behavioral view of man unsatisfying and incomplete. It would certainly be foolish to reject what the behaviorists have taught us, but it would be equally foolish to restrict ourselves within the behaviorist's view of the human mind. We cannot claim to think creatively about instructional processes until we free ourselves to consider the many alternatives offered by the other schools of psychology. A word of caution, however. This kind of freedom should not tempt us into a state of intellectual anarchy. The recent research developments do not tell us that we are now liberated from the rigorous discipline that science insists on in our theorizing, our experiments, and our practical technology. All these developments tell us is that we need not suppose that behavioral psychology has irrevocably defined the parameters and the methodology of learning science.

Where we go from here is pure conjecture. It was not my purpose in the preceding to prove that either rational thinking or so-called creative thinking can be programmed. I have not yet been eminently successful at the first, and have yet to try the second. Nor can I point the direction that programming will or should take after leaving its birthplace in the cages of the animal laboratory. It would even be foolish to assert positively that the door of the pigeon loft is now open, but if you look closely, I think you will see that it is not locked.

RESEARCH IN PROGRAMMED INSTRUCTION: AN OVERVIEW

Leo S. Goldstein

Leo Goldstein summarizes some of the published research on three programming variables: the program, the presentation mode and the learner. The reported studies of program variables show inconclusive differences from variation of step size, knowledge of results or response form. The studies of presentation mode favor the textbook form, but only in terms of efficiency, not effectiveness. Of the many learner variables, IQ appears to be a good predictor of learning with a program. Students making overt novel responses appear to learn better than students told to merely "think" their answer.

Although it is still a relatively young field, a good number of articles relating to programmed instruction have appeared in psychological, educational, and industrial journals over the past few years. In a recent report for the Ford Foundation, Wilbur Schramm estimates the number of articles on programmed instruction appearing in print to be approximately 100. I feel that this is somewhat of an underestimate. It would be impossible, within the confines of this paper, to discuss or even mention all the studies that have been completed.

Therefore, I will try to give you my own "biased" view of the field. I will delineate some of the more important variables and relate to them some of the research that has been done. The appendix was designed to aid you in taking this journey with me through the land of programmed instruction. It lists, for ready reference, some of the landmarks along the way.

According to an ancient Roman, "all Gaul is divided into three parts." Programmed instruction also may be thought of as a tripartite entity. One major division is, of course, the *program itself*. A second, is the *method or mode used to administer or present the program*. The trinity is completed by the *subject or learner* to whom the program is administered. Each of these major divisions may, in turn, be broken down into smaller regions.

Within the program we find, first, the *subject matter*. I would contend that any subject which can be taught can be programmed, if the subject matter can be clearly defined. This is not to say that programming is necessarily the best medium to use to teach any particular subject matter. Some information is probably better taught via instructional methods other than programmed instruction. It is worth noting that a great variety of subject matters such as mathematics, the sciences, foreign languages, computer programming, and even Japanese flower arrangement have been programmed.

The *length* or number of frames of individual programs also has a very wide range. Some programs are designed to teach only one or two concepts and, therefore, are extremely short consisting of no more than a few dozen frames. Others are intended to teach an entire course and they may consist of as many as 10,000 frames.

Some researchers contend that certain effects observed with the use of short programs, such as findings of no significant differences between groups using a scrambled sequence version of a program and those using an unscrambled version, would not appear with long programs. This is probably true, but as far as I know, a definitive study of this question has not yet been made.

Each programmer has his own *style* of writing. Many use what we call a constructed response type of frame in writing a linear program. The material is presented in small bits or steps in a logical sequence in which each succeeding frame is in some way related to the frame or frames which have gone before; within each frame the learner is required to make a constructed response to the stimulus material. After the learner's response has been made, the correct answer is revealed to him. This is the so-called Skinnerian style of programming.

Norman Crowder has developed a style which we refer to as "intrinsic" programming. In this kind of program, the learner is presented with as many as three or four paragraphs of material to read within one frame. He then is required to make a response by choosing the correct answer from a given multiple choice. If the learner chooses correctly, he is sent on to the next frame. If he selects an incorrect response, he is told that he is wrong and why he is wrong. He is given some additional information and is then sent back to the original frame to make another choice. This kind of programming, when used with the textbook format, is the familiar "scrambled text." Of course, these are not the only styles of programming that have been used. Many programmers prefer to be eclectic and will use constructed responses for some frames, multiple choice in others; branching techniques, conversational chaining devices, and any other technique which will help them write a good program.

Of course, now you'd like to know which style of programming is most effective. Truthfully, I don't know, and I doubt that anyone does. Dr. Susan M. Markle at U.C.L.A. is presently doing a comparative study of Skinnerian versus Crowderian programming.

It's my feeling that the superiority of any one programming style would be quite dependent on the subject matter being taught, the mode of presentation used, and certain characteristics of the learner.

Another facet within the larger division of the program is the *step size*. Step size is extremely difficult to define quantitatively or qualitatively. Let me give an example of what is meant by step size. Let us say that I wish to teach concept "Q". I write a program which teaches concept "Q" in 50 frames; a second programmer writes a program which teaches concept "Q" in 25 frames; a third program consisting of perhaps 10 or 15 frames designed to teach concept "Q" is written by yet another programmer. We would then say that the program of 50 frames is a small step program, that of 25 frames is a medium step program, and that of 10 or 15 frames is a large step program. The learner using the first program proceeds by smaller steps than those using either of the other two programs. In fact, he needs 50 small steps to learn concept "Q" while someone using either of the other programs takes fewer and larger steps to cover the same material. Step size, then, is a relative measure. Smith and Moore (1961) of Bucknell University report a study they did with a spelling program. They used a small step, a medium size step, and a large step version of the program. Their subjects were the 5th grade public school students. The results of the study indicate no significant differences in achievement due to variation in step size. Of course, those subjects who used the larger step version completed the program more quickly than those who used the small step version. It should be noted that in this study differences in step size amounted to only two or three frames per word taught.

Another aspect of the program to be considered is *knowledge of results*. After the student has read a stimulus frame, he is usually required to make a response. After responding, the student has the correct answer revealed to him or he is told that the answer he has selected is wrong; in some way he is given an indication of the correctness or incorrectness of his response. This particular feature of programming is sometimes referred to as reinforcement or confirmation but this terminology is loose in that a response can be confirmed only if it is the correct response. An incorrect response cannot be confirmed. Revealing the correct response to the learner after he has responded may be thought of as reinforcing only if this makes it more probable that the learner will repeat the response at some later time when he is faced with the proper stimulus material. A number of studies have been done in which knowledge of results was a major variable. I'd like to mention two of them. The first, using Lewis Eigen's (1960) (1962) *Sets, Relations, and Functions* program was done in the Denver, Colorado school system and was then repeated in the Wauwatosa, Wisconsin school system. Here, one group was given 100% knowledge of results. That is, the correct answer to each frame was revealed after a response had been made. Another group received a random ⅔ knowledge of results. A third group had a random ⅓ of the answers revealed. The fourth group received no knowledge of results at all; they made their responses but were not informed directly whether the response was correct or not. The results indicated no significant differences in achievement due to variation in knowledge of results. The best predictor of achievement was the subject's IQ. Brighter students learned more than duller ones.

The second study concerned with knowledge of results as the major variable was done by Moore and Smith (1962) of Bucknell University. Eleven hundred and fifty-two (1152) frames of the Holland-Skinner constructed response psychology program were adapted to a multiple choice response format. Two hundred and fifty (250) college students enrolled in a one-semester course in psychology were randomly assigned to ten groups. Five of the groups worked with the multiple-choice format of the program, and five worked with the constructed response format. Eight of the groups, four multiple-choice and four constructed response, received instruction via machine presentation. The type of knowledge of results varied for each group. One multiple-choice and one constructed response group used the program as a programmed textbook.

Four varieties of knowledge of results were used: (1) no knowledge of results; (2) immediate knowledge of the correct response where the correct answer was exposed after the learner had made his response; (3) immediate knowledge that the given response was correct; a light flashed when the correct response was made; (4) immediate knowledge of results plus extrinsic reward; a penny for each correct response made was given the learner at the end of each instructional period.

Subjects using programmed texts received immediate knowledge of the correct response by exposing the answer after they had responded.

The results indicated no significant difference in achievement due to variation in type of knowledge of results or mode of response. The findings are consistent with those of the Eigen study previously mentioned.

The second major division which I have delineated is the *method of administering* the program. This may be done via a teaching machine, programmed textbook, index cards, film strip, tape recorder or any audio and/or visual technique that has been developed.

Usually, during the creation of a program, the programmer writes his frames on index cards. As units are completed, the programmer will test his frames on individual students in order to get some feedback; some immediate information about the effectiveness of what he has programmed. After the program has been completed, tested, revised, and put into a more durable form, it then may be presented or administered by a *teaching machine*.

Now the teaching machine, of course, is only the container for the program. Machines range quite widely in size, complexity, and expense. Some of the simpler and less expensive models are designed to hold a program which is usually of the linear style. The learner reads the stimulus frame, makes his response on an answer tape or within the stimulus frame itself, advances the program so that the correct answer is revealed, and then compares his response with the correct one. On some machines, this advancing of the program may be done by turning a knob or pressing a button. Machine presentation of Crowderian style programs is perhaps a little more efficient than a scrambled textbook; the learner using a machine in responding presses a button which automatcially presents the next proper stimulus frame. This saves the learner time in leafing through the text to find his proper place. Some teaching machines have been hooked up to electronic computers which tally responses, compute error rates, and route the learner through the program.

Another mode of presentation of programs is, of course, the *programmed textbook*. In addition to the already mentioned scrambled textbook used for presentation of Crowder-style programs, there are two basic types of texts for presenting linear programs. These are the horizontal and vertical format programmed textbooks. The horizontal format uses several levels of frames on each page. The learner reads across the book, so to speak, on one level, from the front to the back, answering each stimulus frame in turn. When he gets to the back, he turns the book to the front again and starts responding to the frames on the next lower level. The correct answer may appear on the same page as the stimulus frame or on the next page with the following stimulus frame. With the vertical text format, a number of frames again appear on each page but now the learner reads down the page. A mask or slider is used to conceal subsequent frames and correct answers. A number of studies have been reported in which teaching machines have been compared with programmed texts. Dr. Lassar Gotkin and I (1962) have reviewed eight such studies. The general finding is one of no significant difference in achievement between these two modes of presentation. Although no differences in effectiveness have been reported, in four of the five studies in which time taken to complete the program was recorded, a time saving of from 10 to 40 per cent was noted in favor of the programmed textbook format. It is of interest to note that no significant differences were observed, although these eight studies varied greatly in subject matter and the educational level of the learners.

Of the three divisions which I have stipulated, the most complex, of course, is that of *the learner*. Here, a multitude of factors may be studied; to name just a few—age, sex, IQ, educational level, reading ability, socio-economic status, ethnic and religious background. Some work is being done in programming for handicapped persons. Ted Beckmeyer has studied the use of programmed instructional methods with the hard of hearing. He has reported that those of his subjects who had a reading grade level of at least 3.5 were successful with the program used. Other investigations have explored the use of programmed instruction with retarded readers and with individuals of low mental ability. Dr. John M. McKee is directing a school for youthful offenders in an Alabama correctional institution. Here, programmed materials constitute the primary mode of instruction. All these special cases are a real challenge for programmers and the programming art.

In the previously mentioned studies that were done in the Denver and Wauwatosa school systems, one finding was the importance of intelligence as a predictor of success with programmed instructional materials. It was found that individuals of high IQ level performed significantly better than those with lower intelligence. By "performed" I am referring to achievement on a criterion test.

Also related to the learner is his attitude toward programmed instruction and his motivation while going through the program. A good program is self-motivating; it captures the learner's interest almost immediately and carries him along. A number of studies have reported on the attitude of learners toward programmed instruction. The results are mixed. Some learners think programmed instruction is the greatest thing since high button shoes; others think it isn't worth a tinker's dam. In considering these attitudes we have to look at them in relation to the kind of subject matter that is being taught, the mode of presentation used, and the kinds of individuals who are expressing these attitudes.

I have mentioned several times that the learner going through a program reads a stimulus frame and then makes a response. The necessity of subjects' making a response is another factor that has been investigated often. These are the so-called overt/covert, or *response mode* studies. An overt response may be defined as one in which the learner actually makes a motor response and produces some sort of written record which may then be compared with the correct answer. The learner who responds covertly merely "thinks" of what the correct answer might be. Both of these modes of response have wide variations. What may be an overt response in one investigation may be called a covert response in another. In one study the overt response may consist of actually writing out a word or drawing a figure, or it may be pressing a button underneath the right answer. The covert response, may be merely "thinking" about what the right answer is or "thinking" about which button would be pressed in order to make the right response. Here, too, there is variation in the use and definition of terms.

I would like to call to your attention a study of overt/covert response modes with two kinds of learning tasks which were recently completed by Allana Cummings (1962) of the Center for Programmed Instruction. The program used was one which taught the diagnosis of myocardial infarction using electrocardiographic representation of heart damage. The program required the learner to give verbal, that is, written responses, and also to draw picutres of electrocardiograph recordings. It was hypothesized that those learners who made an overt response to the pictorial material, that is, those who actually drew a representation of an electrocardiograph recording would perform significantly better on the criterion test than those who gave a covert response, that is, those who merely thought about what the correct answer should be. The results indicate that this hypothesis is tenable since the overt responders did perform significantly better than the covert responders on this rather difficult, previously unknown material. The overt responders also performed significantly better than the covert responders on the verbal material. This particular finding was not hypothesized because it seemed to the investigators that these verbal responses would be more in line with other material already in the learners' repertoires. Responding overtly proved to be more effective than responding covertly.

This, then, has been a very general overview of the field of programmed instruction with an indication of the kinds of studies that have been done and some of the results which have emerged from these investigations. I think there are possibly a few generalizations that we may make on the basis of these studies. Certainly, the findings indicate that programmed instruction does teach. There are some people, in fact many people who can learn from programmed instruction. People new in the field often ask the question, "How does programmed instruction stack up against teaching by the usual methods?" The only answer that can be given to this question is, "Which program are you stacking against which teacher?" Program versus teacher studies are generally not too fruitful since the results are not readily generalizable to other programs or to other teachers. Arnold Roe, at UCLA, has found that students taught by any form of programmed instruction such as a machine, text, or programmed lecture achieve significantly higher on a criterion test than those taught by the standard lecture. However, I would not wish to generalize from this finding. I am merely calling it to your attention.

I believe we also may say that comparison of teaching machines and programmed texts has indicated that the text format is as effective as present-day teaching machines. This is not to say that this will always hold true; quite probably as the development of machines advances they will become easier to work with and more efficient. For the time being, however, we may say that the textbook is as effective in presenting programmed instructional materials, and in many cases is more efficient than teaching machines.

Although evidence about the efficacy of overt responding is equivocal, it appears, on the basis of the Cummings' study that for certain kinds of subject matter which requires a novel (e.g. pictorial or unfamiliar verbal) response, actually making a response leads to more effective learning than does mere thinking about what the response should be.

In this paper, I have necessarily omitted a number of other variables involved in programmed instruction. The solutions to many of the problems raised are still being sought. As time goes on, still more questions will be proposed for investigation. If future studies can avoid the imprecision of design and definition of terms with which some of the pioneer research has been replete, we can look forward with hopeful anticipation to reliable solutions for some of these basic issues.

RESEARCH ACCOMPLISHMENTS AND NEEDS IN PROGRAMMED INSTRUCTION

Paschal N. Strong, Jr.

Paschal Strong reports a survey of research studies in programmed instruction, finds a few significant implications, many limitations and inadequacies, and indicates the areas in which our thinking and methodology has already changed, and the areas in which research is badly needed.

This paper is not an attempt to review exhaustively the research literature in programmed instruction. Rather, it is an attempt to discuss certain representative types of research in order to assess the gains that have been made and to point out certain methodological and philosophical errors which are prevalent in this research field.

Table I is a summary of 58 studies recently published. They were selected more or less randomly from those journals available to the author. Although they do not constitute a complete population, these studies should serve as a relatively representative sample.

Analysis of these studies can be broken down as follows:

1. Subject variables: size, age, sampling procedures, education, intelligence, and personality measures.

2. Program variables: length, method of construction, efficacy of program validity, appropriateness of program, and subject matter.

3. Independent variables: branching, program vs. "conventional", machine vs. programmed text, response modes, self-pacing or lock-step, types of programs, feedback and reinforcement, step size, and error rate.

4. Dependent variables: pre and post-test comparisons, post-test scores, attitude surveys, time to completion, time to complete post-test, retention, and scores on various kinds of post-test items.

SUBJECT VARIABLES: Analysis of the 58 studies reveals the following information:

1. Twenty-one studies used college students while nine studies used high school students. Thus, over half the references studies came from a highly select, verbally skilled population. The remaining 28 studies used grade school students, except for three which used highly skilled, well educated computer technicians and 14 studies, reviewed by Stolurow, on preliminary work with mental retardates. Since these 14 studies are not of the parametric type to yield the critical data, the final tally indicates that the majority of studies represent a small although important segment of the population. The implications of this skewness of the sample in terms of age, motivation and intelligence will be discussed later.

2. The relationship between IQ and programmed instruction performance is not clear. Reed and Haymen in a treatment-by-levels design found that high IQ students did better with programmed instruction while low IQ students did better with conventional methods. However, since the low IQ groups consisted of problem students in English, it is highly probably that what is called "conventional" instruction is a type of programmed (tutorial) course. Differences in reading ability and capacity to work independently probably explain the superiority of the high IQ group on the English 2600 program. In well developed programs such as the Bell Telephone Labs programs for computer technicians there is a consistent reduction in the variance of post-test scores indicating the ability or programmed instruction to reduce the effect of individual differences. Although the data are skimpy, it is probably true that a good programmed course lessens the effects of individual differences in learning.

3. With the exception of a few studies measuring IQ, reading ability or achievement in a specific area such as mathematics, little has been done to clarify the interaction of subject variables with program variables. Of particular interest would be studies relating such personality traits as anxiety, need achievement, extraversion-introversion, of aspiration and other factors to different types of presentation modes, feedback systems, and program logic, The same should also be done with a more detailed analysis of intelligence such as Thurstone's PMA test, and the subscales of the WAIS. In short, too many have assumed that there is one best type of program for a particular subject matter regardless of subject variables.

PROGRAM VARIABLES: The greatest weakness of research in programmed instruction lies in the area of program variables. Inspection of Table I indicates that in those studies specifying the number of frames used, 13 of 44 had less than 100 frames and only seven had more than 1,000 frames. Consequently, much of the research is based on less than one hour of instructional material and very few were concerned with more than ten hours.

Besides length, another weakness lies in the quality of the programs. Except where commercial, on-the-shelf items are used, such as the Skinner-Holland program, the English 2600, and the Temac Algebra program, there is little information available on how carefully and by what logic the program was derived.

Scores reported on the criterion post-test in many of the studies indicate the programs failed to teach the subject matter to the usual programmed instruction standards. It is pertinent to ask, I believe, how much can be learned about programming from poor, inadequate programs. In many cases the subject matter appears to be chosen by expedience rather than by the students' needs. Thus, the question of motivational factors also contaminates the results.

INDEPENDENT VARIABLES: Keeping the previous remarks in mind, what has been learned about important factors in programming?

1. Branching. In a series of studies, Silberman, *et al,* investigated several techniques of branching. Generally speaking, they and others (Roe, 1962) found forward branching superior in terms of post-test scores and course time, particularly when combined with the student's felt need to branch. A backward review of items did not appear to help.

2. Programming vs. conventional modes of instruction. Although several authors, such as Stolurow, feel that this is an inappropriate question, I tend to disagree. The difficulty lies not in the question posed, but the failure to define conventional and programmed instruction. In the former, conventional is treated as if analogous to lecturing, while programmed instruction is identified as a linear or intrinsic text. Because of these errors of definition, the important measures of efficacy have been overlooked. Good teachers have been implicitly programming their courses for years, although most of them would certainly benefit from some of the more structured, tested programming techniques now in use. On the other hand, a person who takes a standard text and merely uses it to write a series of linear frames is not programming, regardless of the fact that he is supplying feedback, requiring participation, and using small steps.

In spite of these confusions and the poor programs used, in many cases the evidence is remarkably clear. In a series of well done studies on well constructed programs, Hughes and McNamera (1961) showed a significant increase on post test score, along with a significant reduction of time. Other studies (Smith, Wendt and Rust; Hough, Reed and Hayman; Ripple; Legg; Green) indicate either better post-test performances, shorter learning time, or both. I believe that when appropriate measures of reliability are used, we will find even more stricking differences.

3. Machine vs. Text. Surely this particular phase of research is among the most futile ever done. Consideration of this problem as a fruitful area for research can only arise from a profound misunderstanding of the purpose of a teaching machine. The primary purpose of a teaching machine is not to turn pages, present frames, or to prevent cheating; rather, it is a device to guide and shape motor responses. Since all the research in this area was done with purely verbal material the machine was obviously not serving its purpose. Programs such as Sandia Corporation's program for typing chemical equations, are probably far superior with a machine since the terminal response involves a great deal of precise motor movements. Incidentally, in this case the teaching machine is a typewriter. In this light, it is not surprising that no significant differences have emerged from this research. Thus the decision of machine or text must be made on the basis of economics alone, when verbal material are involved.

4. Response Modes. Most of the research in this area has involved either overt vs. covert responding or multiple choice vs. written responses. Generally speaking, the results indicate that the response modes do not differ in terms of final scores on a post-test although the covert and multiple choice modes take significantly less time. This research has been aimed at testing the importance of active involvement and practicing responses. Again, however, there is a failure to define a response. We are not trying to teach writing, button pushing or talking to ourselves. All of these are merely different motor manifestations of the response to the problem or question.

5. Pacing. The few studies done with this variable indicate no superiority for the self pacing group. The programs listed on Table One that are relevant to this question, however, were less than 100 frames. Consequently, there does not appear to be much room for variability in results. Pacing is probably of more importance in programs requiring at least several weeks work.

6. Program Format and Logic. Several questions have been asked by researchers in this regard. Among these are the following:

a. Can programs be constructed systematically according to a specific set of plans, techniques and procedures rather than intuitively?

b. Should missed frames be retained and presented again?

c. What is the best order for items?

Although the data are sketchy, it does appear that a program can be written more or less routinely by the use of the Ruleg principle with as good results as those written by the experienced intuitive programmer and with less effort! Performance is better if missed frames are repeated until correct. Finally, work done by Gagne and Brown (1961) suggests that a program which guides the student to discover and state principles is better than a linear program which gives the principle to the student and asks him to learn it.

7. Feedback and Reinforcement. The several studies done with this variable all suggest that the use of immediate feedback or reinforcement (the difference between the two terms is difficult to specify) apparently confers little benefit to learning. By its very nature, however, a good program is probably unable to present a well developed series of frames without reinforcement. Knowledge, properly presented, is probably intrinsicly "right" to the subject and when knowledge is completely grasped, the subject needs no information as to rightness and wrongness. As far as the term "reinforcement" is concerned, I believe we make a mistake if we discount the reinforcing value of learning or attaining knowledge as opposed to being reinforced in order to make learning occur.

8. Step Size and Error Rate. The few studies in Table One concerned with step size indicate that a good program can be considerably shortened in terms of number of frames, which may make step size larger, without significantly affecting the scores on the post-test. This finding suggests that most commercially available programs, particularly for brighter students, are too long, a statement with which most of us who must review programs would heartily concur. This occurs in spite of a significant increase in program error rate.

In summarizing the research referenced in Table One, it becomes clear that many of the defining phrases used to introduce the lay individual to programming have little to support them. The following list represents some of those phrases or criteria defining a program which, in the light of present research, have little experimental validity: 1. Small steps, 2. Low error rate, 3. Immediate reinforcement, 4. Knowledge of results, 5. Self pacing, 6. Active responding or participation. Caution must be exercised in throwing these out, however, as we move into programming with different subjects and different subject matters. Many of the failures to find significant results may well result from the limited, highly select subjects used, the extremely short and often poor programs, and the inadequate criterion tests.

This last point leads us into a discussion of the dependent variables used, usually a post-test score. Since little information is given concerning the construction of the post-tests, criticism of them is difficult. However, it is, or should be, well known that just as much time and effort must go into constructing a criterion test as goes into defining the program's objectives. Indeed, the criterion test is merely a restatement of the set of detailed objectives and should completely represent that population of facts or knowledge. The trial objectives-program-criterion test should be essentially identical, with nothing present in one that is not present in all. As one member of the triad is revised, all must be checked to see if this congruency is maintained.

Another major variable used is time, and one of the great promises of programmed instruction is that it will lead to a true science of educational efficiency, a highly desirable goal in view of our already overladen educational institutions. Perhaps the addition of physiological measures will allow us to expand this field by use of the concept of work and physiological cost.

A brief point must be made about retention. Most of the research suggests that programmed instruction maintains its superiority over time but is not superior in terms of percentage retention. This should not surprise us since the variables effecting retention are primarily a function of events occurring after learning is over, or events that occurred long before the learning took place (retroactive and proactive inhibition respectively). While a good program may instill knowledge in such a fashion as to reduce interference of both varieties, as yet this goal has not been investigated or built into any program known to this author.

One last critical point must be raised, and this point refers to the apparent lack of consideration of the work done in the last 30 years on human learning. There is almost no citing of the literature concerned with knowledge of results, meaningfulness, retroactive and proactive inhibition, ego involvement or repetition, to mention just a few. Might we suggest a little more thoroughness in looking at previous work? An effort in this direction should serve to yield better hypotheses, save costly repetition of effort, and allow a fusion of the two fields rather than a schism.

A brief statement should be made about future research in programmed instruction. While it is beyond the scope of this paper to discuss this in detail, certain broad areas should be indicated.

1. Greater effort should be expended in relating intellective, emotional and motivational variables to various types of program structures. Of particular interest should be the intellective factors concerned with various sensory modes, and personality variables such as anxiety, need achievement, and extraversion-introversion. It will be found, I predict, that these variables will significantly interact with such program variables as logic (inductive-deductive), step size, error rate, feedback, and structure. The ultimate goal might be different programs for different personalities and intellects.

2. Since all good programs should lead to almost perfect results on the criterion post-test, the important dependent variable will be time and retention as opposed to immediate post-test scores. The inclusion of

other measures, particularly physiological measures, should be considered.

3. The most important effort should now be on program format and logic. I am sure all of us feel that the present linear, infantile, tippy-toe program is not the final answer. Education's final goal has never been solely the attainment of specific knowledge. Rather, it has been to give the tools for attaining knowledge and arriving at new knowledge. Thus the whole literature on transfer of training and creative thought or problem solving must be incorporated into the programming field. If we do not tie into these other streams of research knowledge and ideas, we will simply end up as a different type of textbook writer rather than as contributors to a true science of education. If programs five years from now resemble present programs, we will have failed.

A TABULAR SUMMARY OF RESEARCH IN PROGRAMMING

CODE: E—Experimenter
D—Dependent Variables
N—Subjects
IV—Independent Variables
C—Comments and Results

E: Coulson, J. E., Estavan, P. P., Melaragno, R. J., and Silberman, H. F. *J. Appl. Psychol.* 1962, *46*, 389-392.
N: 30 High school, Frames 233-345 on logic.
IV: Branching vs. fixed sequence.
D: Post test score, 51 multiple-choice items and 44 fill-in items. Time to complete program.
C: Branching superior in time and score on post test.
Good criterion for branching errors and self evaluation.

E: Holland, J. G., and Porter, P. *J. Exp. Anal. of Behavior* 1961, *4*, 305-307
N: 14 college. Frames 2022 Holland & Skinner program on behavior.
IV: Repeating vs. nonrepeating of missed frames.
D: 196 item post test immediate and six months retention. Time.
C: Review of all items missed superior at all difficulty levels and/or retention test.
Time for review adds little to total length of program.

E: Naumann, T. A., *J. Prog. Inst.* 1962, *1*, 9-18
N: 44 College. Frames 631. First 16 sets of Holland, Skinner
IV: None.
D: Time.
Post test (25 items) plus attitude survey.
C: Post test poorly described.

E: Rothkook, E. Z., *J. Prog. Inst.* 1962, *1*, 19-28
N: N=96. Frames 60, color coding of resistors.
IV: Control (just review code)
Mnemonic
Mnemonic & Linear Prog.
D: % correct on post test.
% correct on 48 hour retention.
% correct on 30-100 day retention.
C: % correct all groups=95% thus little room for variation.
Meaningful procedure not used.

E: Goldstein, L. S., & Gotkin, L. G., *J. Prog. Inst.*, 1962, 1, 29-36
Reviews of articles comparing teaching machines vs. programmed texts.
N: 74 high school, 186 college, 63 technician, 60 college, 60 college, 77 8th grade, 87 4th grade, 118 4th grade. Frames 707 sets & relations, 192 probability, 3500 basic electricity, 90 binary, 90 binary & psychol., 65 numbers, 3100 spelling.
IV: Machine vs. textbook
D: Various post test scores and time to complete program.
C: No significant difference between programmed texts and machines in post test scores.
Text consistently take less time than machines.

E: Hughes, J. L. & McNamara, W. J., *J. Appl. Psychol.*, 1961, *45*, 225-231.
N: Maintenance trainees for computer. Frames 719 on computer flow, logic, etc.
IV: Lecture vs. P. I.
D: Post test score.
Retention test.
Time.
Attitude questionnaire.
C: P. I. clearly superior on both post test score and in time needed for program.

E: Hughes, J. L., *J. Prog. Inst.*, 1962, *1*, 43
N: 129 technicians. Frames 719 on computer training.
IV: Reduction of classroom time and method of writing answers.
Overt-covert responding.
D: 88 item multiple-choice.
Attitude questionnaire.
Time.
C: No significant difference on post test.
Time reduced 47% over conventional instruction.

E: Alter, Millicent & Silverman, R. E., *J. Prog. Inst.*, 1962, *1*, 55
N: 60 college. Frames 87 basic electricity.

IV: Response mode:
  a. Writing and saying aloud.
  b. Writing +2.
  c. Speaking control.
  d. Thinking groups.
D: Post test, 22 multiple-choice questions.
C: No significant difference between response modes.

E: Alter, Millicent & Silverman, R. E., *J. Prog. Inst.*, 1962, *1*, 55
N: 60 college. Frames 87 basic electricity.
IV: Response mode and self pacing vs. forced pacing.
D: Post test, 22 multiple-choice questions.
C: Reading better than writing.

E: Alter, Millicent & Silverman, R. E., *J. Prog. Inst.*, 1962, *1*, 55
N: 60 college. Frames 90 on binary numbers.
IV: Overt vs. covert on a text. (The two above were machines) vs. machine.
D: 21 post test items.
C: No significant difference.

E: Shettel & Lindley
N: Frames 30 phonetic alphabet.
IV: Overt vs covert.
C: Covert less time. No significant difference on post test score.

E: Roe, A., *J. Ed. Res.*, 1962, *55*
N: 180 college. Frames 3 probability.
IV: Types of programs:
  1. Linear.
  2. Forward branching.
  3. Backward branching.
  4. Backward alternate.
  5. Pretest forward.
  6. Random order.
  7. Forward branched text.
D: Learning time.
  Error score.
  Post test time.
  Post test score.
C: All branching programs same.
  Random order worst.
  Programmed text not as good as branching.

E: Smith, Nilt, *J. Educ. Res.*, 1962, *55* 417-420
N: 128 college. Frames 337 scrambled books, statistics.
IV: Conventional vs. program. Treatments X levels design.
D: Post test performance.
  Attitude questionnaire.
C: No difference on score.
  Time saved—30%. Program constructed by author.

E: Wendt, P. R. & Rust, G. D., *J. Ed. Res.*, 1962, *55*, 430-432
N: 180 college. Frames not given. On use of library.
IV: Conventional vs. P.T.
  Performance frames.
  Picture frames.
D: Post test score.
  Time.
C: No difference on score.
  Time saved very great but no means given.
  Most important part of study mentioned in passing.

E: Evans, J. L., Glaser, R., & Homme, L. E., *J. Ed. Res.*, 1962, *55*.
N: 60 college. Frames 75 items on symbolic logic.
IV: Initial vs. ruleg program.
  Response mode:
  a. Composed.
  b. Multiple-choice.
  c. Covert.
  Delayed vs. immediate feedback.
  Use of review card as auxiliary memory.
D: A series of parallel test for immediate post test and retention test:
  a. 15 item true-false.
  b. 15 item recall.
  c. 15 deductive proof items.
  d. Attitude questionnaire.
  Time to complete program.
  Time to finish post test.
C: Covert fastest on program, slowest on immediate post test.
  Composed made twice as many errors on program as multiple-choice.
  No significant difference on post by treatments.
  Note reminiscence.

E: Eigen, L. D., *J. Ed. Res.*, 1962, *55*, 453-460
N: 78-8th graders. Frames 65 numbers and numerals.
IV: Machine vs. vertical text vs. horizontal text.
D: Scores on immediate and delayed post tests.
C: No significant differences.

E: Feldhaus, J. F. & Birt, A., *J. Ed. Res.*, 1962, *55*, 461-466
N: 330 college. Frames 37 frames on teaching machines.
IV: Response modes.
  Feedback.
  Pacing.
  Method of presentation.

D: Scores on 15 post test.
C: No difference between experimental groups.

E: Hough, J. B., *J. Ed. Res.*, 1962, *55*, 467-571
N: 41 college. Frames not given subject matter on education.
IV: Teaching machine vs. lecture.
Constructed vs. selected response.
D: Two 50 question T-F tests.
C: Machine superior to lecture on response and time.
No difference between response modes.

E: Krumboltze, J. D. & Bonawitz, B., *J. Ed. Res.*, 1962, *55*, 472-475
N: 32 college. Frames 162 how to write valid achievement tests.
IV: Isolated vs. contextual confirmation.
D: Post test is 13 short essay questions.
C: No significant difference between presentation modes.

E: Reed, J. E. & Hayman, J. W., *J. Ed, Res.*, 1962, *55*
N: About 500 10th grade students. Frames 2632 (English 2600)
IV: Text vs. conventional.
Treatment X level of achievement.
D: Time for course.
Score on post test.
C: High ability did better with P.I. Low ability better with conventional procedure.
Conventional not spelled out.

E: Lambert, P., Miller, D. M., & Wiley, D. E., *J. Ed. Res.*, 1962, *55*, 485-494
N: 552 high school. Frames 843 on sets, relations and functions.
IV: Mode of response X. I. Q. level. Overt vs. covert.
D: Post test score.
C: I.Q. difference significant.
Response mode insignificant.
I.Q. X response interaction is significant.

E: Silberman, H. F., Melaragno, R. J., Coulson, J. E., & Estavan, D., *J. Ed. Psych.*, 1961, *52*, 166-172
N: 51 high school students. Frames 61 on logic.
IV: Fixed sequence vs. branching in a P.I. text.
D: Performance on 24 free response and 24 multiple-choice items.
C: Text branching superior to fixed sequence. Backward review not significantly better than fixed sequence.

EXPERIMENT I AND EXPERIMENT II
N: 36 high school students. Frames 411 multiple-choice on logic.
IV: Branching through easier sequences based on error rate and type vs. fixed sequence. Matched pairs design so that branching member determined sequence for non-brancher. Fixed sequence means a program unresponsive to individual's error.
D: Performance on a 51 multiple-choice post test and 44 free response items.
C: No significant difference.
Note that number of frames varied from 69-248 but no analysis of scores as a function of number of frames.

E: Coulson, J. E. & Silberman, H. F.
N: 80 E, 104 controls, probably college. Frames 105 56 on psychology, not further specified.
IV: Response mode constructed vs. multiple-choice.
Branching vs. non-branching.
Step size.
D: Post test=19 constructed response and 17 multiple-choice.
Retention test in three weeks.
C: Small step learned more but took significantly more time.
Multiple choice faster than constructed.

E: Della-Piana, L. T., *J. Ed. Res.*, 1962, *55*, 502-507.
N: 125 college students. Frames 280 intro. to counseling.
IV: Constructed response.
#1 + cueing.
Copying correct response.
Immediate correction of constructed response by procter.
D: Time.
Immediate post test and 17-day retention test.
C: No difference between response modes.

E: McDonald, F. J. & Allen, D. W., *J. Ed. Res.*, 1962, *55*, 502-507
N: 122 high school students. Frames 27 rules of a game.
IV: Five combinations of information, examples, questions, correction and explanation of corrections.
D: 22 item post test.
C: No significant differences.

E: Taber, J. I. & Glaser, A. J., *J. Ed. Res.*, 1962, *55*, 508-512
N: Variable. Frames 74 on color names.
IV: No experiment in formal sense. Just an attempt to try various transfer modes.

E: Shay, C. B., *J. Ed. Psych.*, 1961, *52*, 98-107.
N: 90 4th grade students. Frames 103, 150, 199 Roman numerals.

IV: Step size of program and I.Q. relationships.
3 step level, 3 I.Q. levels, balanced design.
D: Post test of 31 items with 7 new, transfer items.
Time.
C: No significant differences. Note that step size defined by error rate.

E: Stolurow, L. M. Programmed Instruction for mentally retarded. *Rev. Educ. Res.,* 1963, *33,* 126-136.
Reviews a number of studies in this area.
N: 14 studies here reviewed. Frames.
IV: Seven deal with language (reading, spelling).
Five deal with arithmetic.
Some comparison with normal subjects.
D: Many uses of humans as part of machine.
C: Apparently quite feasible for retardates. Considering lack of personnel to work with retardates this area should be intensively explored.

E: Gropper, G. L., *AID,* 1963, *2,* 214
N: Not given. Frames not given (abstract of res.)
Archimedes law on closed circuit TV.
IV: Visual vs. verbal program.
Active vs. passive.
Visual and verbal in two orders.
D: Immediate post test.
Delayed retention test 2-3 weeks later.
C: Visual better than verbal on visual tests items.
Reverse true for verbal test items. Total test score same.
Visual/verbal better order than verbal/visual.
Active superior to passive. Note: This is on a TV program!

E: Ripple, R. E., *AID,* 1963, *2,* 218-220
N: 240 college. Frames 134 on P.I.
IV: Responding vs. reading.
Conventional lecture. Read program to students.
P.I. but no answers (no reinforcement).
D: Post test:
a. 25 multiple-choice.
b. 25 recall items.
Parrallel retention test.
C: Programming significantly superior to lecture and reading.
Reading superior to lecture.
Reinforcement not necessary.

E: Bartz, W. H. & Darby, C. L., *AID,* 1963, *2,* 207
N: 34 college. Frames TEMAC: Algebra II.
IV: Supervised P.I.
Unsupervised P.I.
Traditional lecture.
D: Purdue placement test.
Algebra achievement test.
C: No significant difference btween traditional and supervised P.I.
Unsupervised was inferior.

E: Moore, J. E. & Smith, W., *AID,* 1962, *2,* 188-189
N: 96 5th graders. Frames 1108, 838, 596, on spelling.
IV: Size of steps: small, moderate, large.
D: Post test consisted of spelling 50 words.
C: Large step equally effective as small step program.

E: Legg, O., *AID,* 1962, *2,* 135
N: N=480 high school. Frames approx. 500 on agriculture finance.
IV: P.I. vs. conventional lecture.
Blackout vs. erasure feedback.
D: Post test and 2 months retention test.
C: Both learned, lecture significantly better.
P.I. 5 hours, conventional 12 hours.
Erasure better than blackout.

E: Green, E. J. & Sykes, C. A., *AID,* 1962, *2,* 124-125
N: 23 medical students. Frames 154 on autonomic nervous system.
IV: P.I. review vs. reading assignments.
D: 62 item post test by people who did not make program.
Time.
C: P.I. superior to reading on both relevant and transfer items.
Less time also, so that efficiency of P.I. significantly better.

E: Asher, J. J., *AID,* 1961
N: 80 college. Frames 92 Spanish vocabulary.
IV: Visually (picture)—aurally vs. aurally—visually.
D: Score on vocabulary post test.
C: Visually-aurally superior performance.

E: Kaes, W. & Zeaman, D., *J. Exp. Psych.,* 1960, 12-17
N: 435 college. Frames 30 psychology definitions.
IV: Positive and negative knowledge of results.
D: Number of errors second and third time through program.
C: The more alternatives, the poorer the learning.
Not really a test of negative KOR.

E: Cagne, R. M., & Brown, L. T., *J. Exp. Psychol.,* 1961, 313-321
N: 33 9th and 10th graders. Frames 89 items + 30 number series.
IV: Ruleg program.
Discovery.
Guided discovery.
D: Post test = 4 new problems on series.
C: Guided discovery best Ruley—worst.

THE EFFECT OF WITHHOLDING REINFORCEMENT IN AUTOINSTRUCTIONAL PROGRAMS

James L. Becker

James L. Becker's paper concerns an RCA Educational Services experiment on withholding of reinforcement. The study supports the hypothesis that a person using an auto-instructional program in which the steps are kept small and well prompted will learn without the usual confirmation. Two groups of students were given identical programs except that the experimental group received no confirmation of correct responses. There was no significant difference between the acquired knowledge of the two groups.

"I learned a lot," Ricky commented. "That program stuff is very interesting."

The interviewer scanned the post-test; indeed Ricky had acquired a considerable amount from the 200 frames on Symbolic Logic. "What did you think about getting your answer immediately after each frame?" the interviewer pressed. Ricky's bright red hair drooped as he assumed a querying countenance.

"What do you mean?"

"The answers here on the answer sheet", said the interviewer calmly, pointing to the indicated portion of the programmed text.

"Oh, that," Rick said, "I hardly ever looked at that."

Not many students were as candid as Rick in discussing their attitude toward the reinforcement. There was other evidence of students neglecting the reinforcement. Some branching existed in the program in question; yet many students went through routines in the program which they were entitled to skip if they had bothered to look at the answers. The evidence points to the fact that people do not always choose to refer to confirmation even when it is readily available.

Perhaps the phenomenon can be explained by this theory. Solving new and challenging problems is reinforcing in itself. The correctness of the solution is irrelevant. As long as an individual thinks that he has found an adequate solution to a problem he is reinforced. The many existing contradictory philosophies, ideologies and theories and the dedication of their respective proponents are a living testimony to this fact. When a person doubts the validity of his solution, anxiety is born and he acts to diminish the anxiety. In this circumstance we have a definite need for reinforcement. In this situation reinforcement will contribute to learning. If, however, the anxiety is not effectively reduced by confirmation, unhealthy aggression or withdrawal from the learning situation may result.

One hypothesis that can be derived from this theory is that a person will learn equally well without confirmation provided the steps are kept so simple that the student has confidence in all his responses. This does not mean that complex repertoire should not be constructed. It only means that new matter must be adequately prompted at the beginning and that the prompts can be gradually and completely withdrawn.

Recently RCA was developing some materials for the Philadelphia National Bank on Time Credit Loans. They agreed to allow RCA to investigate reinforcement in their program. A program of 180 frames was designed which consistently used strong prompting and total prompt reduction. This program also fulfilled entirely the training requirements of the company.

The following data will aid in further describing this program:

1. Average time per frame: 22 seconds.
2. Correlation of acquirement to intelligence: —0.03.
3. Correlation of intelligence to program completion time: +0.17.
4. Mean pre-test score: 33%.
5. Mean post-test score: 84%.
6. Size of sample: 10.
7. Type of sample: Stratified, paired groups.

The sample was divided into two groups matched according to intelligence, knowledge of the subject matter, experience, age and former education. The control group was given the program with reinforcement for every frame. The experimental group received no reinforcement. Immediately after the program both groups were tested. The difference between the mean scores of the two groups was 6.7%. This was not significant.

Although acquirement in both the experimental and the control group was significant at the .01 level, the difference between acquirement of the two groups was not significant. This finding is compatible with our theory that reinforcement is only effective when it reduces anxiety; however, this does not yet constitute proof or adequate substantiation of our theory. Further research will be required.

The observation that, aside from overt reinforcement, there are other principles contributing to learning in a program, and that these other principles may account for much of the acquirement, is an essential point for further research. This is important not only from a theoretical point of view, but also from the purely practical point of view of enabling us to write better programs.

PROACTIVE AND RETROACTIVE EFFECTS IN PROGRAMMED LEARNING

J. E. Gerber, Jr.

J. E. Gerber is interested in developing a way to teach new responses to old stimuli. He devised a type of program that uses the old response as a mediator or bridge for the new one. The bridge association is pointed out explicity in the content of key frames. His data support the conclusion that the explicit bridging approach may work well if the student has a good grasp of the old stimulus—response association.

Inducing students to abandon obsolete associations and replace them promptly and accurately with new associations is a problem for instructors in subject areas in which new developments occur requently. In the military, for example, long-held, well-integrated concepts of organization, means, methods, and equipment frequently must be discarded in favor of new ones.

The literature on the dynamics of learning new responses to replace old ones presents a somewhat confusing picture, as may be seen in a comparison of the writings of Guthire (1935), Carr (1960), Amsel (1960), and Hilgard (1956). But if there is validity in Skinner's postulate, that strength of the association (or operant) is measured in terms of increased probability of response, then teaching the new response without extinguishing the old is not likely to strengthen the new association to a magnitude significantly greater than the old. Stated another way, solely on the basis of strength of association, the learner is no more likely to respond with the new response than he is with the old. And even if he does respond with the new, the mere elicitation does not guarantee, according to Blyth (1960), that material presented in auto-instructional form is either learned or understood. Now if programmed material is presented in such small steps that the learner can distinguish the new response from the old response to the program frames but yet does not learn new associations, a conflict in relative strength of the old and the new may be postulated.

The present experiment was designed to test the efficacy of a method of programming rapidly changing instructional material in such a way that for a given stimulus a new response rather than a previously correct one is elicited and retained.

Table 1 depicts the experimental design. The 170 Ss, male junior officers of the Army Medical Service Corps, were pre-tested for knowledge of the phonetic alphabet used by the Army (Appendix I). Beside each of 25 stimulus letters they were to write the phonetic response word if they knew it. Most knew some of them. The Ss were similarly tested for knowledge of 25 military symbols used on maps. On the basis of error scores on this old phonetic alphabet, 3 groups were formed similar as to N, mean, standard deviation, median, mode, and range. In each group the model error score was 25, the maximum; the modal frequency being 10, 10, and 9 respectively for Groups 1, 2 and 3. The remainder of each group had at least some knowledge of this old alphabet at time of pretest on day zero.

Six days after pretest, Groups 1 and 2 studied auto-instruction Program 1 on the same, old alphabet on which they had been pre-tested. The program was linear, 77 frames including criterion test on all 25 letter-word associations. (Sample frames are in Appendix I.) Group 3 studied a similar program on military symbols. All Ss finished the alphabet program well within the 30 minutes allowed. Criterion test results are shown in Table 1.

Five days after first programs, two forms of a second program were given on a new phonetic alphabet. The new phonetic alphabet and sample frames from the alternate forms, Program 2A and Program 2B, are given in Appendix II. Each program was linear, 65 frames including criterion test. To the old stimulus letters, A, B, C, for example, the new responses, Acre, Bolo, China were required rather than the old responses, Alfa, Bravo, and Charlie. In Program 2A, the "bridging" version studied by Group 1 frames that introduced each new response word identified both the old and new words, discussed or bridged similarities and differences between them, then required S to choose between the old and new. Subsequent frames required practice of the letter-new word association. In Program 2B, the nonbridging version studied by Groups 2 and 3, the old word was neither identified nor discussed, but S was required to choose and underscore the new word in the presence of the old on the introductory frames. The 30 minutes allowed for completion were more than adequate. Results are given in Table 1.

Five days after second programs, new alphabet, then old alphabet criterion tests were readministered as retention tests. Group results on learning and retention tests are given in Table 1. Significance of differences of group means is shown in Table 2.

For further analysis, Groups 1, 2, and 3 were subdivided on the basis of error scores on the old alphabet pretest given on day zero. Those with error scores of 0-10 (60% or better correct) were called "high knowledge"; "low knowledge" was 11-25 errors. Sub-group means on learning and retention tests and significance of differences between means are shown in Table 2.

Two conclusions with regard to bridging as used in this study are offered:

1. Bridging apparently facilitates retention of new responses by subjects with well-established high knowledge of old responses to common stimuli.
2. Bridging apparently lowers retention of new responses by subjects who have little or no knowledge of the old responses to common stimuli.

		0 day	*6 days*	*5 days*	*5 days*	
		Pre-test	*First Program*	*Second Program*	*Post-tests*	
		Old Alphabet	*1, Old Alphabet*	*2A, New, Bridging*	*New Alphabet*	*Old Alphabet*
Gp 1	M	15.96	.63	1.07	4.38	2.32
N=56	O	8.13	.22	2.23	4.78	2.76
	M	18	0	0	3.25	2.06
	M^{d}	25 (10)	0 (33)	0 (36)	0 (14)	1 (16)
	R^{o}	1-25	0-5	0-12	0-18	0-14
				2B, Non-bridging		
Gp 2	M	16.17	.70	1.48	6.70	1.02
N=60	O	8.02	1.39	2.23	6.57	2.86
	M	19	0	1.08	4	1.88
	M^{d}	25 (10)	0 (40)	0 (29)	1 (10)	1 (17)
	R^{o}	1-25	0-8	0-9	0-23	0-12
			S, Military Symbols			*Symbols*
Gp 3	M	15.46		.89	3.11	
N=54	O	7.99		1.74	3.66	
	M	14		0	.93	
	M^{d}	25 (9)		0 (35)	1.5 (14)	
	R^{o}	1-25		0-9	0-17	

Table 1

Comparison of distributions of error scores of Groups 1, 2, and 3. Elapsed time from pre-test to end of post-test is 16 days

	Groups 1, 2, 3 *N: 56, 60, 54*		*High Knowledge* *N: 17, 17, 16*		*Low Knowledge* *N: 39, 43, 38*	
	Learn	*Retain*	*Learn*	*Retain*	*Learn*	*Retain*
Group 1	1.07	4.38	1.35	2.35	.97	5.10
Group 2	1.48	6.70	1.06	6.35	1.65	6.88
	t= .97	t=2.13*	t= .43	t=2.41*	t=1.25	t=1.31
Group 1	1.07	4.38	1.35	2.35	.97	5.10
Group 3	.89	3.11	1.06	3.13	.84	3.11
	t= .45	t=1.29	t= .51	t= .40	—	t=2.14*
Group 2	1.48	6.70	1.06	6.35	1.65	6.88
Group 3	.89	3.11	1.06	3.13	.84	3.11
	t=1.47	t=3.42**	—	t=2.71*	t=1.63	t=2.44**

*5% level.
**1% level.

Table 2

Significance of differences of means of error scores of the groups and subgroups on new alphabet criterion and retention tests

Appendix I

"Old" phonetic alphabet and sample frames from Program 1

ALFA
BRAVO
CHARLIE
DELTA
ECHO
FOXTROT
GOLF
HOTEL
INDIA
JULIETT
KILO
LIMA
MIKE
NOVEMBER
OSCAR
PAPA
QUEBEC
ROMEO
SIERRA
TANGO
UNIFORM
VICTOR
XRAY
WHISKEY
YANKEE
ZULU

Program 1 Card 3

The first letter in the alphabet is A, and the word used for A in the phonetic alphabet is ALFA. Write ALFA on the solid line. ____________

Program 1 Card 15

Now see how well you have done. (Don't go back to earlier cards. Try to remember.)

The word for A is____________.
The word for B is ____________.
The word for C is ____________.

Appendix II

"New" phonetic alphabet with sample frames from the "bridging" (2A) and "non-bridging" (2B) programs.

ACRE
BOLO
CHINA
DADDY
EERIE
FUR
GORGE
HILLTOP
INDIGO
JULY
KITE
LULU
MONK
NIKE
ORANGE
PEPPER
QUOTE
RIP
SIMPLE
TOT
UNDER
VIOLET
WISH
XRAY
YELLOW
ZOO

Program 2A Card 3

THE NEW PHONETIC FOR LETTER A IS ACRE. ACRE HAS THE SAME NUMBER OF LETTERS AS ALFA, THE WORD YOU ALREADY KNOW FOR LETTER A. IT IS THE WORD, ACRE, THAT YOU ARE TO LEARN. NOW, STUDY THE TWO WORDS BELOW:

UNDERSCORE THE NEW WORD FOR LETTER A.

ACRE ALFA

Program 2B Card 3

THE PHONETIC WORD FOR LETTER A IS ACRE. ACRE IS A 4-LETTER WORD BEGINNING WITH LETTER A. IT IS THE NEW WORD, ACRE, THAT YOU ARE TO LEARN. NOW, STUDY THE TWO WORDS BELOW:

UNDERSCORE THE NEW WORD FOR LETTER A.

ACRE ALFA

Program 2A Card 7

AFTER BOLO COMES CHINA, THE WORD FOR LETTER C. YOU HAVE LEARNED CHARLIE FOR LETTER C IN THE OLD ALPHABET, BUT YOU MUST NOT USE THAT WORD HERE. CHINA IS THE WORD FOR LETTER C.

UNDERSCORE THE WORD FOR LETTER C.

CHARLIE CHINA

Program 2B Card 7

AFTER BOLO COMES CHINA, THE WORD FOR LETTER C. CHINA IS THE WORD FOR LETTER C.

UNDERSCORE THE WORD FOR LETTER C.

CHARLIE CHINA

EXPLORATIONS IN STUDENT-CONTROLLED INSTRUCTION

Robert F. Mager and Cecil Clark

Robert F. Mager and Cecil Clark describe a number of studies possessing common features in which students controlled the learning experience. Learners were encouraged to indicate which topics should be discussed, how deeply they should be explained, what equipment or demonstrations were required, the frequency of reviews and the length of instructional periods. Instructors respond to questioning but do not provide unsolicited information or explanations. Findings showed a decrease in training time, variations in content sequencing, an increase in student competence and confidence, and achievement comparable to conventional instruction methods. The authors recommend that techniques be developed for the determination of the background level of students permitting individualized curriculum adjustment which will induce an economic progression to the course objectives.

The development of programmed instruction is, or certainly should be, a dynamic undertaking. While we may differ widely and even wildly on what programming will ultimately be like, few would question that we have a way to go before we attain the ultimate. In short, some changes are indicated. The interesting thing about this is that, although most of us will acknowledge that change is necessary, we are ignoring some of the facts that indicate where changes should be made.

In this paper, we want to suggest an area in which program design can be improved. We shall try to accomplish our purpose by briefly describing a few studies, identifying some common features of these studies, and then by suggesting what course of action is indicated. As our discussion proceeds you will undoubtedly be struck by the fact that there appears to be little, if any, new information. Even the conclusions we draw from the data have been known about and talked about by educators for years. What would be new and what we advocate would be the widespread *application* of these well-known facts; and what would be novel would be for us to practice what we preach.

Most of the studies we will describe are those in which the learners were given a good deal of control over the learning experience. As a matter of fact, it was this very feature in these experiments that led us to rediscover the astonishing phenomenon that adult learners enter a formal learning situation with previously gained knowledge *relevant* to the learning at hand.

The first study was undertaken about four years ago by Mager (1961) to discover whether a learner would sequence instruction in the same way that an instructor typically sequences it. If the sequence of information called for by a learner was radically different from that prescribed by an instructor, it might be inferred that a course sequence generated exclusively by the instructor or the expert was less meaningful to the student than it might be. To explore this problem, one student at a time was given complete control over a curriculum in electronics. The instructor tried to behave like a mechanism that would respond to the student's questions, but which would offer no unsolicited information or explanation. The learner was encouraged to indicate which subjects he wanted to discuss, how deeply he wanted to have them explained, the kinds of equipment or demonstrations he felt would be useful, and the frequency and nature of reviews. The learner also controlled the length of each instructional session. Results of this study indicated that the sequence of information called for by the learner was considerably different from that of the traditional electronics curriculum. Also, the fact that the student had a good bit to say about the procedure seemed to exert a strong and favorable influence upon his motivation. These results were indeed interesting and provocative, and have led to further studies and to applied programming. In the programming department of Varian Associates, for example, at least two subjects are now interrogated before any program frames are written so that guidance relative to information sequencing can be obtained from members of the target population.

In addition to the results just described, a rather nagging phenomenon was repeatedly observed. No matter how ignorant the learners appeared to be, no matter how slowly they appeared to learn, no matter how naive they claimed to be, male and female subjects *each* entered the experiment with some *relevant* knowledge about electronics. Some of the subjects knew more than others, of course, and one or two had developed some rather interesting misinformation about the subject. Nonetheless, no subject started with zero relevant knowledge.

The second study (Mager and McCann, 1962) was an applied industrial experiment conducted in one of the manufacturing divisions of Varian Associates. The study involved an engineering course, six months long, given newly graduated engineers before they were permanently assigned to their positions. Training included theory, machine and instrument operation, manufacturing processes, and company procedures. The first six weeks of the course were devoted primarily to formal lectures; during the second six weeks each trainee was rotated through the various departments through temporary assignment to the manager or expert in each of the departments. During the last three months of the course the student was assigned as an assistant to an experienced engineer. Because of the small classes involved (four to eight students), each student received what amounted to six months of individual instruction.

Our experiment again called for a good deal of control on the part of the student. All classes were cancelled and the instructor was asked to "speak only when spoken to." Students were told that they would have complete control over what they learned, when they learned it, and how they learned it. They were told that they could ask for instruction from anyone in the division, but that they were not to accept instruction they did not want. One important difference between this study and the previous one was that this time the students were given 24 pages of detailed course objectives which specified the desired terminal behavior. The total effect was that the students had to decide what they needed to learn *in addition to what they already knew* in order to reach the objectives.

Some of the results of this study were:

a) Training time was reduced 65 percent. All students were permanently assigned six to eight weeks after training began.

b) The graduates of this program appeared better equipped than those of previous cycles, demonstrating more confidence and more knowledge about manufacturing processes and microwave theory. The manager of the division considers these engineers "better trained" at the time they assumed their permanent responsibility than previously hired engineers.

c) Considerably less time was devoted to training by the instructor, administrators, and technical experts.

d) Content selected for study varied considerably from student to student.

e) The sequence of information studied varied from student to student, but in no case coincided with the sequence used previously.

Though no instructional programs were used in this study, it still appeared possible to significantly reduce the length of a formal training program, while at the same time improving the competence and confidence of the student. This result was obtained primarily by providing the student with a detailed description of the desired terminal behavior, and by allowing him to fill in the knowledge gap between what he already knew and what was required. Put another way, he was not required to relearn what he already knew. Since some of thse students had been previously trained as electrical engineers, some as industrial engineers, and some as mechanical engineers, it was known that they entered the course with a considerable amount of relevant knowledge, which would help account for their rapid progress. It was noted, however, that students in previous cycles also came in as trained engineers.

A third study (as yet unpublished) that we would like to mention also investigated content sequencing. This study used the skill of electrical meter reading as the vehicle. During the early phases of the study we wanted to determine empirically the meter reading skill of several kinds of experts. An automated meter reading examination was thus administered to a group of physicists, a group of engineers, and a group of technicians. The final score for each of these groups was approximately 80 per cent. When housewives were given the same examination *without any prior training,* their average score on the examination was 40 per cent. Again, although these subjects all claimed ignorance in this area of electronics and meter reading, and although they had no formal training this or related areas, their performances were significantly better than zero and half as good as those of the experts. Unlike the previous study, here is an example of a group of students entering a training situation supposedly with a minimal amount of relevant information; obviously, however, these housewives possessed a considerable amount of relevant knowledge.

Still another experiment (Mager and Clark, 1963) provided results indicating that the *expert was no better than* the naive subject. The object of this particular study was to determine whether a qualitative knowledge of result could be used to teach a subject information for which there was no right or wrong answer. Specifically, the object was to determine whether subjects could learn to discriminate different smoothnesses of metal surfaces when their responses were confirmed by the percentage of expert agreement with the response rather than by an indication of correctness or incorrectness. To complete the device used in the experiment, it was necessary to obtain expert judgments. The stimulus items were therefore judged by thirty-six experts and their average judgment wired into the machine. For this experiment an "expert" was defined as a person who had final authority over the disposition of the metal materials in question, rather than in terms of skill.

The result of this study that is relevant here is that the performance of the experts turned out to be identical in every respect to that of the control group receiving no training whatsoever.

While the previous experiments we described suggest that students frequently know more than we give them credit for, the results of this smoothness experiment suggest that some experts know a good deal *less* than we give them credit for. In other words, the behavior of the expert, or should we say instructor, may not be as different from that of the layman as he would like to have us believe. But while it may be more comfortable to talk about engineers in this way than about ourselves, we have similar problems closer to home. There have been countless studies, for example, in which the ability to predict human behavior was studied as a function of training and experience level. The ego-deflating results have uniformly demonstrated that the predictions of those naive organisms commonly referred to as "college sophomores" and "underpaid secretaries" were essentially as accurate as judgments made by highly trained and experienced clinical psychologists. The expert, in other words, didn't make judgments any better than the novice. We also suspect that the judgments of "experts" in other disciplines, if subjected to a reality test, might not justify the confidence or the credibility attributed to their pronouncements.

In an experiment conducted at Stanford last spring (Allen and McDonald, 1963), subject were required to learn the pieces, rules, and strategies of a new game. One group learned from a linear program, while each member of another group was provided with objectives and an instructor that he could turn on and off at will. The members of the group which had control of the curriculum performed almost as well as those learning from the linear program, but they required only *half* the instruction time required by those using the program. A peculiar observation made during this study was that while the subjects of the experiment were bright Stanford students, those in the group which had control of the curriculum exhibited no skill at systematic information collection. In other words, had you watched these subjects you would probably have predicted poor terminal performance because of the chaotic way in which they asked questions of their information source. Nonetheless, this group performed almost as well as the program group, in half the time.

The general conclusion we draw from these studies is that adult students are likely to enter a learning situation with a significant amount of relevant knowledge; in other words, they are likely to already know something about that which is to be taught.

Let us examine some possible implications of such a conclusion. Is this new information? Certainly not! One of the oldest rules of teaching exhorts the teacher to "take the student from where he is to where you want him to be." Presumably this means that one should start instruction at the edge of the student's knowledge; to start beyond the edge of his knowledge is to construct unnecessary obstacles in the path of his learning, and to start within his knowledge is to bore him. The incredible thing is that we are well aware of the existence of differences in student knowledge and experience. At the same time, however, we behave as though we wished this difference would go away. We are willing to recognize that students enter instruction in various stages of *un*-preparation, and we apply remedial procedures to the learner to minimize his lack of preparation. But the questions to be raised are, why don't we also recognize that students may enter instruction in various stages of *over*-preparation, and why don't we apply remedial procedures to the curriculum? Certainly we admit the existence of "overpreparation" every time we decide to "control" an experiment by using a pre-test. Yet, in programming, the overwhelming tendency is to cause each learner to work his way through exactly the same sequence of information; this is true for both linear and branching programs, even though the branching program allows students to omit a good many remedial discussions. What we seem to have overlooked is the possible advantage to be gained by subtracting from his curriculum that which the learner already knows. There is, after all, no reason to believe that the only way to obtain further improvements in instructional efficiency is through the improvements of programs and teaching machines! We submit that it is timely to begin thinking about curriculum-generating machines! These devices would be designed to detect what the student already knows, compare this body of knowledge with that required by the objectives of the program, and then generate a curriculum for the student. The result would be a saving in student time equal to the time it would take to teach him what he already knows relating to the instructional objectives, minus the time required to detect the state of his knowledge; boredom would also be reduced.

There is another possible implication that can be drawn from our conclusion. In the absence of a curriculum-generating machine, the adult learner himself might be a better judge of what he needs to add to his current knowledge in order to reach some given set of objectives than is a textbook writer, instructor, or programmer. Given half a chance and a set of reasonable objectives, he will probably generate for himself a curriculum that will lead him to achieve these objectives. Interestingly, this implication is not without support. There are several studies performed by professors (Duke, 1959; Milton, 1959; Weitman and Gruber, 1960) who have allowed one college class to attend all the lectures while prohibiting another group from any lecture attendance. Even in the absence of carefully specified obejctives, students of the group who were not allowed to come to class performed just as well as those in attendance. While this is not conclusive evidence that teachers aren't necessary, the data suggests that we might improve the efficiency of instruction by making better use of the intelligence and background which the adult student brings to the formal instructional experience.

Thus, the new frontiers in program design that appear to be fruitful are these:

1. The development of effective methods for detecting the relevant background level of the incoming student, and for adjusting the curriculum accordingly.
2. The development of techniques which the learner himself can use to efficiently generate a curriculum which will lead him as economically as possible to the objectives.

To summarize, while we feel that further improvement in programming can be achieved by continued research with variables having to do with subject matter *presentation,* we suggest that greater improvements can be attained by focusing on variables relating to subject matter *selection.*

PARTIAL AND CONTINUOUS FEEDBACK IN A LINEAR PROGRAMMED INSTRUCTION PACKAGE

Walter E. Driskill

Walter Driskill investigated the effects of partial and continuous knowledge of results in a linear program. One group of students received 100% feedback, the other group received feedback on an aperiodic 40% of the frames. Prior laboratory research suggests that continuous feedback should enhance learning, but aperiodic feedback should increase retention. Mr. Driskill observed no such differences. Learning and retention scores were almost identical for both groups.

In the literature on programmed instruction there is almost unanimous agreement that the provision of immediate knowledge of results constitutes reinforcement of a learner's responses and contributes materially to his learning. This immediate feedback feature is frequently cited as being one of the primary requirements for an effective linear program (Porter, 1957; Carr, 1955; Merrill, 1961). Skinner (1954, 1958, 1960), in establishing some of the principles of linear programming, stated that "immediate feedback (is used) not only to shape (a learner's) behavior but to maintain it in strength." A lone dissenter in the role of feedback is Crosier (1960) who proposes that knowledge of results may be desirable, but feedback in his system is not provided for its reinforcement effects. The primary reason for providing knowledge of results is to determine whether the communication of informational material has been successful.

Programmed instruction packages being prepared today, both commercially and in the military, without exception provide for immediate confirmation of the correctness of a learner's responses. Even branching type programs contain feedback information that may have reinforcing values.

The importance of reinforcement in facilitating learning has been established in many studies (Woodworth, 1954). More specifically, some of the early experimental work in programmed instruction dating from the time of Pressey (1926) and Little (1935) indicate that in a test situation those students receiving feedback concerning the correctness of their answers learned more efficiently than students who did not receive such feedback.

There is a comparable body of literature dealing with the question of partial and continuous feedback. This literature was reviewed by Jenkins and Stanley (1950) and Lewis (1960). These reviews suggest that response strength is generally greater under conditions of continuous feedback during acquisition but resistence to extinction is greater when partial reinforcement conditions are used.

Because these general findings pertain to schedules of reinforcement, a study was undertaken to determine the effects of partial and continuous feedback in a linear programmed instruction package.

One hundred ninety-four airmen undergoing basic military training were assigned to two treatment groups. Airmen were not individually assigned but the flights to which they were randomly assigned upon entering training were randomly assigned to the two treatment groups. These airmen completed a 52-frame linear program on powers and roots of numbers. This program provides instruction on the derivation of powers and roots of numbers, exponents, and fractional and decimal exponents.

The linear program was presented in two ways. One group of 97 airmen comprising the regular reinforcement group completed the program as it was originally developed. Each learner responded in each frame and was able to turn to the next page and compare his response with the correct response provided there. He was able, in other words, to confirm the correctness of his response immediately after he had responded. The second group of 97 airmen completed the program which had been altered to provide feedback only on 40 per cent of the frames on a periodic basis. The first ten frames remained as they were originally developed with the correct response printed on the page following the frame. The remaining 32 frames were presented so that the correct response was deleted from 70 percent of the frames.

Three parallel forms tests were devised. Each was a 12-item test which measured specific principles included in the power and roots program. The first test was used as a pre-test administered prior to training. The second test was administered immediately after the trainees had completed the 52-frame program. The third test was used as a measure of retention and was administered seven days after the learner had completed the program. Comparability of groups was determined by use of general aptitude index scores taken from the Airman Qualifying Examination. The groups did not differ significantly in aptitude, the means scores being 53.1 for the regular group and 54.6 for the irregular reinforcement group.

Scores that each learner made on the pre-test, post-test, and retention test were recorded. Mean scores for each test were computed and t-tests of differences between mean scores on each of the tests were made. The resulting t ratios are shown in Table 1. Here is seen that no differences between treatment groups occurred for pre-test, post-test, or retention test.

In Table 2 the achievement gain for each reinforcement group is shown. Each group made gains significantly beyond the .01 level. This gain was computed by taking the differences between the pre-test and post-test scores for each student.

In Table 3 the extent of retention loss is shown for each reinforcement group. As shown, neither loss is significant. Likewise, the difference in loss between groups is not significant.

As a result of these findings, the conclusion is that for this program continuous feedback did not facilitate learning nor did irregular reinforcement facilitate retention. These findings are contrary to the general findings pertaining to the question of partial and continuous feedback.

Another conclusion is that the program did an efficient job of instructing since significant gain was noted for each group and the retention loss after seven days was very slight.

As a result of this study, the question naturally arises concerning the requirement for continuous feedback. More pertinently, it may raise a question as to what is the role of feedback in a linear program. It is suggested here that feedback is a reinforcing agent in the linear program until the student has learned that he can respond correctly by using the cues and prompts that are provided in frames. Feedback provided early in a program may reinforce correct responding behavior. Once this behavior is established, feedback may be unimportant in the remainder of the program. The theoretical implications for learning theory and for programming instruction of this possibility should be explored.

TABLE 1

Summary Analysis of Test Scores for Each Reinforcement Group

Test		*Regular*			*Irregular*		*Mean Difference*	*t-ratio*
	N	X	S	N	X	S		
Aptitude	97	53.1	—	97	54.6	—		
Pre-Test	97	3.2	2.4	97	3.3	2.5	.1	.193*
Post-Test	97	8.8	4.7	97	8.1	4.4	.7	1.910*
Retention Test	97	8.0	2.9	97	7.5	2.9	.5	1.208*

* Not significant at the .05 level (two-tailed)

TABLE 2

Achievement Gain for Each Reinforcement Group

	Pre-test Mean	*Post-test Mean*	*Gain*
Regular	3.2	8.8	5.6*
Irregular	3.3	8.1	4.8*

* Gain is significant beyond .01 level

TABLE 3

Retention Loss for Each Reinforcement Group

	Post-test Mean	*Retention test Mean*	*Loss*
Regular	8.8	8.0	.8*
Irregular	8.1	7.5	.6*

* Neither loss is significant at the .05 level

(Note: The difference in loss between groups is not significant.)

AN EVALUATION OF PROGRAMMED INSTRUCTION AND CONVENTIONAL CLASSROOM TECHNIQUES

Maurice A. Larue, Jr. and F. Elaine Donelson

Maurice A. Larue and Elaine Donelson of the Martin Company performed a comparative experiment on the efficiency of programmed instruction using conventional instruction, a programmed text and a teaching machine on a 19-hour segment of the "Fundamentals of Computers" in a weapon system training course. The experiment showed no significant increase in learning using programmed instruction, but it did show 25 percent time savings. The experiment forbade the experimental groups from studying at home, but permitted the control group to study at home.

With programmed instruction being heralded as a new and efficient tool in the technology of learning, we at the Martin Company were interested in determining whether or not this technique would have application to our weapon system training program.

An experimental program was designed and initiated to determine primarily the efficiency of using this technique to teach, and secondarily, to investigate variables which may influence learning with programs. The primary questions, which are the focus of this paper, were: (1) Can a programmed course teach?; (2) If so, to what level of proficiency does it teach compared to conventional classroom instruction?; (3) Does it take more, less, or equal time, as compared to conventional time to attain this level of proficiency?; and (4) Are the answers to these questions dependent upon the presentation technique of the programmed course?

Additionally, secondary questions included whether or not relationships would show up between education, verbal and mathematical aptitude, attitude, and gain and time. These questions are discussed in a report published by Martin Orlando (Larue, Donelson 1963).

Because our chief training needs are weapon system training, a segment of the existing Pershing Weapon System New Equipment Training Course was selected as the course material for the experiment. This segment, "Fundamentals of Computers," was a nineteen hour classroom portion of instruction on the Pershing Fire Data Computer and was subdivided into six lessons. The terminal objectives for each of the lessons had been predetermined by Pershing Training personnel and established in the Plan of Instruction (POI) for each lesson.

This material was programmed using intrinsic or branching techniques; the behavioral objectives specified in the POI were retained in full. The six lessons and the objectives of each were:

1. Number Systems: The objective of this lesson was to make the student aware of various number systems such as the binary, tertiary, octal, and decimal. He was to learn the terminology peculiar to number systems (radix, coefficient, etc.) and how to express a number in a particular system mathematically.
2. Number Systems Conversions: The objective of this lesson was to teach the student to convert both whole numbers and fractions from one number system to another. The number systems involved were decimal, binary, and octal.
3. Binary Arithmetic: The objective here was student mastery of addition, subtraction, multiplication, and division of decimal, binary, and octal number systems. Knowledge of complements in each system was also an objective.
4. Computer Language: Here, the student was to become familiar with computer terminology. He was to learn what a general purpose digital computer consisted of and the relationship and function of each of its units.
5. Computer Logic: The objective here was to teach the student the general logic associated with a general purpose digital computer such as the relationships which existed between logical "1" and logical "0" inputs and outputs for various gating circuits.
6. Computer Building Blocks: The objective of this lesson was to teach the student the function and use of the seven major computer building blocks used in the Pershing system.

A behavioral objectives test was prepared for the program. It was of the same multiple-choice format used throughout the branching program and was designed to have at least one question per each prime frame in the course. Preparation of the test in this manner allowed its use both in the preliminary evaluations of the programmed course and in the evaluation of student performance.

Subject matter experts and the Pershing training instructors reviewed the programmed material and, after their suggested changes were incorporated in the courses, endorsed its technical validity. The program was then tested empirically with students. For the initial test, four subjects, selected to represent the range of the target population, took the course presented in a "scrambled book." On the basis of their comments and the item statistics provided by the objectives test, revisions were made in the program.

Six subjects, selected from men assigned to take the course as part of their training, were used to test the revised program. On this test, presentation of the material was by machine. Their performance and comments resulted in addition revisions. For the experiment itself, the material was presented to the students in three ways. The classroom, or control group, received conventional platform lectures. The book experimental group used 6″ x 8¼″ spiral bound scrambled books designed so that information on one page was not directly related to information on the adjacent page. The machine experimental group used the U.S.I. Mark II Autotutor. The course content in all three cases was the same, and was designed to provide mastery of the same behavioral objectives. In the case of the two experimental groups, the material was identical with the exception of information relating to machine and book operating procedures.

A total of 70 subjects was used. All were adult male military personnel who were required to have an EL score of 100, shown by actual test scores or officer status. Fifteen were available to serve as the conventional group; thirty for the machine group and 25 for the book group. All three groups were tested for their knowledge of the course material both before (pre-test) and after (post-test) taking the course. The previously mentioned behavorial objectives test consisting of 174 multiple-choice questions was used in both cases.

The conventional group received 19 hours of regular classroom instruction and could study at home as they wished. Both programmed instruction groups were told to go through the course as fast or as slow as they felt was needed to master the material. For these groups no instructor interaction was allowed nor was any home study permitted.

Knowledge of the course material before instruction was compared to knowledge after instruction to determine if the programmed course had taught. For both the machine and book groups, achievement scores after instruction were significantly higher than before ($p < .01$); learning did occur as a result of using the programmed material. The classroom group also showed a significant increase in knowledge as a result of their instruction.

Post-test scores were analyzed to determine if there were any differences in the achievement level attained by the three groups of subjects receiving the instruction by the conventional, machine, and scrambled book methods. The influence of initial differences in knowledge of the material was controlled by covariance, which increased the precision of a simple analysis of variance by 59%. No significant differences occurred among the three groups; there is, then, no reason to say that one group learned more than another. Table 1 presents the means and variability measures of each of the groups on the pre- and post-tests. Also shown are the post-test means adjusted, by the covariance technique, for pre-test. The conventional groups adjusted mean was 65.8 percent compared to 71.4 and 69.9 percent for the machine and book groups.

Considering variability, however, the data indicate that the variance of post-test scores for each of the programmed instruction groups was significantly larger than that of the conventional group ($p < .05$). However, this was true for the pre-test also. Comparing pre- and post-test variances for each group shows that in no case was there a significant difference between variability before and after instruction. While the obtained differences are in the direction of an increase in variance after instruction for all three groups, this increase was not significant.

It is interesting to note that these data do not support the hypothesis that programmed instruction reduces variability in achievement scores. Claims have been made that programmed instruction is the great educational equalizer. In theory, this appears to be a completely reasonable claim. In a conventional class, all individuals are exposed to the same material for the same length of time. Because of the individual differences of the students in understanding and mastering what they have been exposed to, the variability of proficiency scores should be directly proportional to the

Means and Variability of Achievement Test Scores

	Pre-Test %	*Post-Test %*	*Adjusted Post-Test %*	*Gain* %*
Conventional				
Mean	47.93	67.86	65.82	38.67
Standard Deviation	5.87	7.82		10.79
Range	36-59	49-79		11-53
Machine				
Mean	46.67	72.32	71.40	49.93
Standard Deviation	13.03	13.44		16.02
Range	26-71	43-91		17-79
Book				
Mean	42.99	67.56	69.89	45.24
Standard Deviation	12.10	15.40		19.70
Range	28-68	42-90		3-72

$$* \text{Gain} = \frac{\text{Post-pre}}{\text{100-pre}} \times 100$$

Table 1

variability of these individual differences in assimilation.

In the experimental group, under the conditions in which our experiment was conducted, the problem of time competition of individuals might have tended to overshadow the importance of proficiency and artificially reduced time variability. Each man could readily tell how much progress the other men had made with the course in relation to his own. Few men care to finish last. Therefore, the subjects may have taken time only to partially master the material in an attempt to keep pace with the class. Perhaps if each student was permitted to take his course completely isolated from his classmates this competitive factor would be circumvented and the time-proficiency-variability relationship hypothesis supported.

Many assumptions as to why variability was not reduced with programmed instruction could be debated, but unfortunately we have no facts to support any at this time. In any event, it is an interesting area deserving experimental investigation.

In the comparison of times for the groups, measures of time are of the time taken to complete the course once. Breaks are included but lunchtime is not. The time spent in classroom instruction for the conventional group was fixed at nineteen hours for all subjects. The nineteen hours, however, did not include any home study which was known to have occurred for many students. Since there was no control or accurate measure for the extra time for the conventional group, the programmed instruction group's times are compared to 19 hours.

Table 2 shows the average times taken by subjects using machines and books were 14.53 and 13.64 hours, respectively. Thus, the machine group showed a 24% time savings and book group 28%. The difference between each of the programmed instruction groups and the classroom group are statistically significant ($p < .01$). The difference between the programmed groups is not significant.

In summary, we found that for our selected 19 hour course, "Fundamentals of Computers," personnel using the branching program completed the instruction in significantly less time than did the classroom group and that they did so without reduction in proficiency. The obtained non-significant differences between the three groups in achievement were in favor of the programmed course. Finally, it was noted that although some variability of time did occur with programmed instruction, no decrease in the proficiency variability resulted.

Time Used by Conventional and Programmed Instruction Groups

	Conventional	*Machine*	*Book*
Mean Hours	19	14.53*	13.64*
Time Savings	—	24%	28%
Standard Deviation	—	2.66 hours	3.50 hours
Range	—	7.20-21.10	8.47-19.72

* Significantly less than 19 ($p < .01$).

Table 2

Using the same group of subjects a further analysis of the data was made to determine if there were differences in the way in which use was made of time depending upon whether the mode of instruction was programmed or conventional. The student of today is educated in an environment where the fifty-minute hour is the widely accepted classroom work-rest cycle. In this environment he is exposed to the material he is to master for fifty minutes of each hour. He is then given ten minutes free time to use as he sees fit. He repeats this cycle until that "magic hour" when he has been exposed to all the material determined as essential to the particular course.

Administratively, then, the problems of handling personnel are kept to a minimum. A class starts on day X and finishes on day Y, a day known even before day X begins. All men of the selected class can be treated as a single entity. Scheduling is made relatively easy; personnel loads and teacher availability can be more readily matched; classroom needs can be better predicted, and so on.

But the administrative problems are not the only problems which must be solved. In reality, the primary problem which should be solved in a learning situation is the problem of teaching and student learning.

Unfortunately, the two seem to work against each other. The establishment of a learning environment which minimizes the administrative problems tends to magnify the problems or establish roadblocks in the learning process. This occurs because the material to be mastered must then be doled out to the individuals at a pace predetermined by those training specialists who developed the plan of instruction (POI) and then this pace is further modified to suit the need of the instructor or trainer who is responsible for transmitting the information to the students.

This established time element, when coupled with the individual differences of the students, results in one of a number of things occurring. First, the established time can be set or adjusted to the intellectually low-average element within the class. This usually results in having most of the class pass the course, but it accomplishes this at the sacrifice of, and to the detriment of, the intellectually bright or fast student. Or second, the established time can be adjusted to the average within the class. But this does two things in that either fewer persons master the material, and pass the course, or that more students must spend substantially more time in home study just trying to keep abreast of the class. However, it is generally found that this home study is required by those who are in need of the intellectual intercourse normally provided by the instructor, which is a need that cannot be satisfied in home study.

Devotees of programmed instruction claim that one of the major benefits of the application of this new technology to the learning environment is the self-pacing feature which allows each student to proceed along at his own pace through the material. In this manner each student of every class is exposed to the same material and is neither speeded up beyond his capabilities nor required to drag-his-heels because of his slower classmates. But immediately the administrative problem is brought up and the question as to how will we be able to handle these people administratively is sounded throughout the land.

While this paper does not intend to cover the entire problem of the administrative-learning relationship, it does seek to discuss one of the probable causes of the many faceted administrative complex relating to student self-pacing or student control of his own time.

What does happen when a student is given permission to regulate his study and break needs as he feels they should be so that he may best learn the material? Our concern with this area was to determine if this self-regulation would result in the students' actually taking more clock-time to go through the course than the nineteen hour limit, 2 eight hour days and 3 hours, allocated for the classroom learning of our selected course.

It was felt that a time increase could result from the students' taking excessive breaks, extended lunch hours, working shortened days, or any combination of these factors, and that this behavior would be due to one or two factors. First, the student would require longer breaks and shorter exposure time now that the learning process was entirely through his reading the material rather than through the media of an instructor, thus resulting in increased fatigue on the part of the student. Secondly, it was felt that with this new found freedom, some of the personnel would tend to take advantage of the situation and take more break time than they really needed, just because it was now available to them.

In an experiment, designed to compare conventional classroom with programmed instruction with regard to time and ability to teach, the students who were taught by programmed instruction were allowed to pace themselves and control their own work-rest cycles. They were told specifically that they were to take as many breaks as they felt they needed, of as long or short a duration as they felt necessary. The conventional group (N = 15) operated in the normal fifty-minute hour work-rest cycle.

At this point a difference in data collection of the two groups should be noted. One experimental group of 30 subjects using Mark II Autotutors, and another consisting of 25 students using a programmed text were timed to the nearest minutes for all breaks taken. The procedure used was to tally a break time anytime the student left his assigned desk and to mark the break concluded upon his return. For the conventional group, no such timing procedures was used; break time was based only on the accepted classroom schedule which called for a ten minute break every fifty minutes.

The comparison of breaking behavior of the three groups is best seen in Table 3.

The conventional group, as controlled by the fifty-minute hour, took the normal thirty minutes each morning and afternoon as brought about by the three ten minute breaks each session. The reason for only three ten minute breaks each session for the conventional group was the overall daily schedule by which they abided, Table 4. The similarity of the two experimental groups in their breaking habits is readily depicted by the first three columns of Table 3. Both groups averaged more breaks per man in the morning sessions than were taken in the afternoon sessions and the time per break averaged slightly longer in the mornings than for the afternoons. In all cases the average number of breaks was less than that for the conventional group.

Because of the freedom of self-pacing allowed the programmed instruction group over that of the classroom group, it was thought that the reduction in number of breaks taken could be caused by personnel taking extended break times, extended lunch hours, starting late, or leaving early on each day thus resulting in their not needing as many breaks because they were not there as long as the accepted eight-hour day.

Break Data

	Breaks/ Man	*Time/ Break (Min)*	*Break Time/ Man (Min)*	*Single Break Range (Min)*
Conventional				
Mornings	3	10	30	—
Afternoons	3	10	30	—
Machine				
Mornings	1.24	15	19	1-57
Afternoons	1.12	13	15	1-87
Books				
Mornings	1.26	19	23	1-63
Afternoons	1.07	14	15	1-42

Table 3

The distribution of the time-per-break data is shown in Table 5. Because so few of the personnel took extended breaks it seems safe to assume that the influence of these few on the number of breaks needed woud be negligible. Also it may be seen in Break Time/Man column of Table 3 that extended break times were not predominant in their occurrences.

In looking at the lunch hour comparison, Table 6, it is seen that the average time taken for all student lunches is only six minutes longer for the machine group and one minute less for the book group than was normally allotted these people.

A detailed analysis of the "excessive" lunch hour data revealed that there were no real violators in the book group and that only four men took excessive lunch hours in the machine group. In each of these cases it is readily stated that these persons were in a position to see the end of the course in sight and thus were able to take more time for handling of personal business or just to enjoy the luxury of a long lunch.

One excessive lunch, 132 minutes, was taken when a man finished lesson 5 at 1030 in the morning. With one more lesson to go, the entire course was divided into six lessons, he left and returned at 1242.

Daily Schedule

1st Period	0730-0820
2nd Period	0830-0920
3rd Period	0930-1020
4th Period	1030-1120
Lunch	1120-1240
5th Period	1240-1330
6th Period	1340-1430
7th Period	1440-1530
8th Period	1540-1630

Table 4

Break Length

		% Breaks	
	Machine Groups	*Book Groups*	*Classroom Group*
1- 5 minutes	28%	22%	—
6-10 minutes	16%	17%	—
10 minutes	—	—	100%
11-15 minutes	19%	14%	
16-20 minutes	17%	11%	
21-25 minutes	8%	18%	
26-30 minutes	4%	7%	
31-60 minutes	7%	10%	
60 minutes	.6%	.8%	

Table 5

Lunch

	*N**	*Time (Min)*	*Range (Min)*
1st Day	15	80	—
2nd Day	15	80	—
3rd Day	—	—	—
All		80	
Machine			
1st Day	29	83	33-179
2nd Day	15	94	75-132
3rd Day	1	67	—
All		86	
Book			
1st Day	23	85	84-94
2nd Day	12	68	43-88
3rd Day	—	79	

* Varying Ns for machine and book groups was brought about by personnel finishing course in varying times, due to self-pacing, or by taking an entire halfday session off, again a self-pacing feature, but one which also occurs with students in conventional classes.

Table 6

A second extended lunch, 179 minutes, occurred when the man was already on lesson 6.

The third extended lunch, 178 minutes, occurred from 0932 to 1230 and this man was on lesson 5.

The fourth extended lunch, 114 minutes, occurred with the man on lesson 6.

In each of these instances the total time for these men to finish the nineteen hour conventional course was less than nineteen hours and in some cases was less than the average of the experimental groups.

It might be said, then, that extended lunch hours might have had some influence on the number of breaks taken by the experimental groups, but that this influence would have been negligible. Because only four persons took long lunches, it is felt that, had they conformed to the 80 minute lunch, they each might have taken one more break in the morning, but in the aggregate this would not have caused the 1.24 breaks per man figure to approach the conventional three breaks per man.

The third influence on breaks might well have been the student's freedom to select his own starting and finishing time. Detailed analyses of this data showed that in the machine group all personnel were in before 0800 (0730 normal start time) each day, and that for the book group only one man came in after 0800 (0805), and two men worked only a half day each for one of the days.

For the afternoon leaving time, a different picture does appear which tends to justify the lower "number of breaks" values shown in Table 3 for the afternoon sessions. Normal departure time was 1630 hours. For the book group this was generally adhered to. However, on the first afternoon three persons (N = 24) left before 1620 (1435, 1534, and 1546 hours) and on the second afternoon six (N = 21) left before 1620 hours. What is interesting to note is that six out of the nine departures on the two days were persons who had just completed a lesson and did so within 45 minutes of normal quitting time. It was a good stopping point. For the other three, no justification is apparent from the records.

In the machine group the same phenomena appeared. On the first afternoon, five left early and four of these had just completed a lesson. On the second afternoon, fifteen left early with ten being at a known convenient break point.

Because of these early departures, it is probable that, had all personnel been required to stay until 1630 hours, the 1.12 and 1.06 breaks per man averaged in the afternoon might have been brought up to the 1.24 and 1.26 level average of the morning. It is doubtful that it would have brought the average up to the conventional three per session.

It is interesting to note that, of the 55 experimental subjects, only four exceeded nineteen calendar hours and that of these, three required in excess of nineteen hours exposure just to learn the material. The fourth required eighteen hours and 59 minutes to learn the material, or one minute less than nineteen hours.

Thus it appears as though the concern related to students exceeding a conventional time standard by controlling their own work-rest cycles in a learning environment is, on the whole, not supported. Students using programmed instruction actually took fewer breaks for any given time session than did their classroom counterparts. While they took longer break periods, the total break time per man per day, or half day session, was substantially less than the time allowable on an enforced 50 minute hour pattern.

It should also be noted that the difference from the conventional schedule in time per break, Table 3, may be only an apparent difference due to the procedural techniques of measuring the break time of the programmed instruction students while simultaneously merely accepting the "take-ten" break time of the classroom group. When one recognized the fact that the conventional ten minute break often exceeds an actual ten minutes time, then it might even be concluded that programmed instruction groups took less than half as many breaks and took no more time per break than they would have been allowed in a normal military learning environment.

It is felt, however, that the behavior patterns manifested by this experimental group can lead to one or two possible assumptions. The first, that the breaking habits noted here were notably different than those to which the subjects were normally exposed because of the novelty and newness of the teaching or educating mechanisms. Because the students found it necessary to work only an average of fourteen hours before they felt that they had attained mastery of the material, it can be theorized that the exposure time was sufficiently short so that the so-called "pin ball" effect had not had an opportunity to dissipate. This then raises the question, "Would continued exposure and/or familiarity with these new programmed instruction techniques result in different breaking or work-rest patterns?"

The second, and perhaps more far reaching, assumption is the one which says that the work-rest cycles exhibited during this experiment are true indications of what students need in order to optimize learning. Perhaps the behavior elicited by those students who were able to control their own breaking patterns, fewer breaks of slightly longer duration, does really suit the needs of more people and perhaps should even be investigated for potential application to classroom use.

Perhaps 50 minutes, while sufficient to warmup to the learning task, is not long enough to realize maximum benefit of the warmup period so essential to the overall learning process. Perhaps the problem of having to stop and start three times each morning and each afternoon results in less actual learning than would occur if the students took less breaks of longer durations during any given learning environment. Unfortunately our experiment can provide no answer here, but it does raise the question for speculation.

In summary, then, our investigation of work-rest cycles for programmed instruction students showed that these students took substantially fewer breaks of slightly longer duration than did their conventional counterparts. In addition, we found that students who took extended lunch hours, or who worked shortened days, did so because they were near the completion of the course, or because they had completed a lesson near quitting time and took the lesson completion as a good stopping point. It was also found that students who required more than the conventional time to finish the course materials took less breaks than their conventional counterparts, and that these breaks were also of a shorter duration.

THE UNINVITED

Lois-ellin Datta

This author discusses certain very real dangers that programmed instruction presents. The rigorous and specific development of course objectives might well reinforce "uninvited guests" inadvertently included in the program, as well as attitudes and perceptions that will emphasize rigid, dogmatic inflexibility instead of the capable, freely inquiring minds that are our objectives. She reports data that indicate that dogmatic thinkers apparently interest more effectively with linear programs than do less dogmatic students. The implications are thought provoking.

Since confession is supposed to be good for the soul, I have a confession to make. I used to be a conventional teacher, and I've carried some of the interests from my conventional days into programmed instruction. I would like to share with you one of these concerns—I am going to talk about authoritarianism and programmed instruction. I will begin by showing how such uninvited guests may enter when we open the door for course content. In the second part of the discussion, I'll review the meaning of the authoritarian complex of fascism, rigidity, and dogmatism. Then I'll present evidence we discovered which indicates that a typical programmed course may be reinforcing dogmatism along with diodes. This evidence will be discussed in detail later: to put it bluntly, dogmatic students did better in a programmed course. My guess as to the "whys" is a bit of a long story, but I hope you will bear with me because the ethical problems raised by the data are significant and are likely to be with us for a long time.

My first point is that while we know that a valid programmed course teaches the goal behaviors, we do not know what else may be learned at the same time. As I was leafing through "The Analysis of Behavior" the other day, I came upon a list. It read, in part, "Reduce alcoholism. Increase the nutritional adequacy of the average American diet, and demonstrate the contribution of formal logic to creativity." Sounds pretty varied, yet these have all been given, and recently, too, as goals of education. The list is a sort of Exhibit A for one of the five ways in which the conventional course differs from programmed instruction. The educational goals of the conventional course are usually many and fuzzy. It would be hard to tell from some of the objectives whether you were looking at a design for a course in physics or one in home economics; either—or neither—could reduce alcoholism and touch on creativity. The educational objectives of a programmed course, on the other hand, *MUST* be specified in clear behavioral terms, and the program is designed to teach just these observable goal behaviors. We say, in fact, that clear specification of the goal behavior is one of the benefits programmed instruction has conferred on conventional education. We believe that teachers who use the analytic frame-work of programmed instruction are more likely to get where they want to go because they now know where they're going. And we know, of course, that programmed instruction can provide the best road.

After a programmed course on extraction of the square root, Susie can extract a square root—and that's that. Or is it? It seems to me that we may have fallen into a fallacy here which I think logicians call the Pathetic Fallacy, and it is pretty pathetic. A valid programmed course by definition is one through which the student achieves the initially specified goal behaviors and many programs succeed in being valid with admirable consistency. But we do *NOT* guarantee that these goal behaviors *AND ONLY THESE* behaviors are reinforced. And when we stop for a minute, it doesn't seem likely that we ever *can* claim that only the course content is being taught. I do not think, as one example, we can separate reinforcing course *content* from reinforcing the properties of the *structure* within which the content is presented. And the non-content extras can be valuable, neutral, or disastrous. I believe we have developed tunnel vision in our specification of very limited terminal behaviors. This seems to apply to knowledge of subject matter (we are, for example, probably reinforcing sentence structure as well as sentence content) and to more elusive changes. This is pretty obvious if we talk about conventional instruction. A lot of kids have low opinions of the educational process, not just English I, when they quit school at 16. Now let's put the shoe on the other foot—our foot. The usually positive attitude students express towards programmed courses certainly suggests they are learning something about this kind of teaching technique—yet most of the programs I've seen haven't listed, "Increase positive responses toward programmed instruction on attitude Scale I" as a goal behavior. The goals of the programmed courses do say very clearly what is wanted and if the program is good, I've found that the knowledge is there. But the goal specifications say nothing at all about what is *not* there or about what else the wind blew in when the door was open.

My second point is that uninvited guests are chancy creatures. They are sometimes very pleasant. The story of the three princes of Serendip who had a genius for finding what they were not looking for has become very popular. But there is also the much older legend of Pandora's box; quite uninvited evils were inside along with Hope. I am going to tell you about one such guest which may be hidden among the welcomed aspects of programmed instruction. This guest is part of the complex of authoritarian attitudes. It is not part of the content and I think it comes in with the structure.

Let me review with you the meaning and measurement of the authoritarian complex. Authoritarian attitudes sounds like a gen-u-wine fright word and it is. The major study goes back to World War II, when the consequences of fascism were seared into the awareness of most of us here. The brutalities which men, civilized men, committed on other men—and women, and children—seemed to go far beyond a superficial attitude veneered on the German psyche by a demagogue. And some social scientists thought that underneath the many varieties of intolerant behavior was a single attitude structure of fascism. By fascism they meant bootlicking the boss, kicking the kids, and hating your neighbor, a basic personality structure developed from very early childhood experiences. These social scientists developed a measure for fascistic tendencies which they called the F scale. It included items such as, "obedience and respect for authority are the most important virtues children can learn," and they found that subjects who were high in fascistic authoritarianism were indeed anti-Semitic, politically conservative and generally ethnocentric. But other social scientists found that the F scale didn't measure quite what it should, that while it reflected acceptance of far right social ideas, it failed to discriminate between the totalitarian attitude of the Communist, the intolerance and inflexibility of the professional liberal, and an open-minded approach to belief systems. I've used the term "belief system" here for the first time and I'll be using it frequently from this point on. Let me define it. A belief system is all the beliefs, sets, expectancies or hypotheses that a person at a given time accepts as true about the world he lives in. Rokeach and his social scientist associates (1960) have succeeded in differentiating at least three levels of authoritarian beliefs. The F scale, they found, did indeed reflect the specific ideological content of the far-right but they discriminated at least two more tendencies. These tendencies are structural. That is, they reflect not the content of a belief system but *how* it is developed and maintained. The first more inclusive tendency is rigidity, which is defined as resistance to change within the *elements* of a belief system. A person with rigid educational expectations, for example, would be resistant to change in the *specific operations* of teaching. The chap with rigid educational expectations would resist unscrewing the chairs from the classroom rows and grouping them around the teacher. An example of an R scale item is, "I am often the last one to give up trying to do a thing." And Rokeach found a still more general tendency which he called dogmatism. Dogmatism is resistance to change in belief *systems* by intellectual conviction. The highly dogmatic individual doesn't balk at a change in the elements but has difficulty in resynthesizing them into a new and different belief system. He could, for example, accept moving the chairs all over the map as long as the *process* of absorb-what-the-teacher-says was unchanged by the physical differences. An example of a D scale item is, "young people should not have too easy access to books which are likely to confuse them." Rokeach describes a dogmatism continuum with a closed-minded side and an open-minded side. On the closed-mined side, he would identify extremists of all persuasions and on the open-minded side, he would identify individuals with a willingness to explore the evidence for a change in elements and the ability to synthesize them into a new belief-disbelief system, to restructure and evaluate freely.

I have spoken at some length to define the authoritarian complex. None of the characteristics about which I'm speaking—racial and religious intolerance, fascistic authoritarianism, rigidity and dogmatism—evokes a pleasant picture. They aren't meant to because the social situations with which they are associated can be pretty horrible. All in all, they sound like attitudes to be avoided. And my third point is that one of the frequently mentioned educational goals in the list which fluttered out of "The Analysis of Behavior" some minutes ago *is* avoiding closed-mindedness. The statement is more usually positive—to foster a critical and free understanding, to develop a way of thinking which can generalize beyond the specific subject matter to form an approach to other areas of knowledge and behavior.

In the past 15 years, there has been an increasing concern about the development of the freely inquiring mind. The pocketbook sincerity of this concern was demonstrated when the Mellon Foundation financed in the 1950's a very ambitious and extensive evaluation of the extent to which the aims of a liberal education were being reached. The Vassar study also yielded many interesting data, as such studies do. Among the data was the encouraging evidence that in conventional college courses, authoritarian tendencies were usually negatively related to achievement. This negative relation had been previously reported, of course, with the F-scale and achievement, and in subsequent non-Vassar studies, scales of the authoritarian complex reassuringly continued to be negatively correlated with grades in high school and college.

You may be wondering what all this has to do with programmed instruction. Nothing, one would wish, or at least, the negative correlation between achievement and closed-mindness should continue to be reported for programmed courses. Few programmers would hope they are reinforcing dogmatism, rigidity, and prejudice along with information about reading circuit diagrams. But in point of fact, we think that in its typical use, authoritarian attitudes and programmed instruction may have a lot to do with each other, for we found a high positive correlation between dogmatism and achievement in a linear programmed course administered in a fairly typical manner.

Let me tell you what we did, what we found and what we think it all may mean. We are Education and Training personnel at the Missile and Space Division of the General Electric Company. The Missile and Space Division is responsible for research and development of re-entry and orbital systems and we are responsible for supporting this effort by appropriate educational activities such as in-plant courses. After reading the articles in *Look* and *The Reporter,* and listening to some of you who are here tonight, it seemed to us that programmed instruction, under optimum conditions, has tremendous promise for education, and what were we waiting for? The trouble was that no one could tell us just what these optimum conditions were, and the few systematic studies such as Roe's (1960) that we found suggested that either there were no optimum programming conditions or they hadn't yet been found. Undaunted, we've been trying to search systematically in other pastures for optimum conditions of student, administration and criterion variables. (Datta, 1963)

In one such study, we were field-testing a programmed course in solid state electronics. The three-section course is a 3000 frame linear program; response was overt and a consulting instructor mode of administration was used. The consulting instructor met the students six times for testing and to answer their questions; he was available *ad libitum* in between to answer questions but he didn't take the initiative in leading a discussion or suggesting supplementary material. Three groups of Missile and Space Division personnel participated in the study. They were all applicants for the in-plant, after-hours, voluntary education program. All had a speaking knowledge of electronics and all swore they really needed the course for their jobs. The groups varied in pacing but since pacing did not affect achievement and since the effects which I'm leading up to were replicated, the data I'm going to present are for 30 pooled Ss. The men submitted to a few tests, including the three scales of the authoritarian complex, a measure of general mental ability, a test of basic electronic theory, precourse knowledge of transistors and finally, three post-tests, one for each section. The criterion achievement tests were *NOT* in any sense test frames. They were developed by the instructor on the basis of course content to measure what a chap who claimed knowledge in the content areas ought to be able to do regardless of how he was trained. The split-half reliabilities of all three measures were high and content validity was judged satisfactory by the program authors.

Now that I've told you who we are and what we did, let's consider what we found. The results are shown on this chart (see Table I) as the correlations between the three authoritarian complex scales and achievement on post-course test I and as the percentage of subjects high, average and low on each scale who were above the median on post-course achievement.

The correlation of F scale performance and course achievement, —.17, was zero-order. 80% of the students in the lower third, 60% of the students in the middle third, and 20% of the students in the upper third of the F distribution were above the median in course performance.

The correlation of R scale scores and post-course test I achievement was —.42. The percentages of students in the lower, middle and upper thirds of the R distribution who achieved scores above the median on test I are 90%, 60%, and 10%, respectively. The correlation of D scores and achievement is +.53; 70% of the high D scorers, 80% of the middle D scorers and 10% of the low D scorers were above the group median on test I.

The results are consistent with Rokeach's differentiation and are, to us, quite thought-provoking. The low correlation between the F scale and achievement probably reflects the lack of political content in a course on solid state electronics.

We are not at all sure what accounts for the latter

Table I

Percentage of Students in the Upper, Middle, and Lower Thirds of Attitude Scale Distributions Above the Median on Post-Course Test I

Scale	*Upper*	*Middle*	*Lower*
Fascism	20%	60%	90%
Rigidity	10%	60%	80%
Dogmatism	70%	80%	10%

Rank-Order Correlation of Attitude Scales and Post-Course Test I Performance

	RHO
F/Achievement	—.17
R/Achievement	—.42
D/Achievement	+.53

two relationships. One explanation is that the educational expectations of the high D students are consistent with the structure of linear programmed courses administered as this one was while the educational belief systems of the low D students are consistent with the more inductive approach traditionally found in in-plant courses. One interpretation of the negative R/achievement relation is that the open-minded low R student adjusts rapidly to differences in the *elements* of programmed and conventional instruction but the high R students' greater resistance to change is at least initially a handicap. One would expect on the basis of these analyses that if you asked the students to describe the "typical" course and the programmed course, you'd find two kinds of differences. The first kind of difference is qualitative. Students high in R would describe structural *elements* of the educational system. Students high in D would describe the *system* itself. The second kind of difference is quantitative. Students high in R would probably have 180° between perceived typical and programmed course characteristics. Students high in D would have *congruent* lists for typical and programmed courses while for students low in D, the lists would not agree. We are currently conducting several follow-up studies, measuring the authoritarianism/achievement relation in traditional in-plant courses, the effects of educational expectations, of fact vs. problem-solving criteria, and so on.

The point I am raising here is that while the programmer has an obvious charge to meet the course content objectives, we might also consider our responsibility to determine what else besides the stated behavioral objectives is being reinforced through course structure and administration. In an in-plant course on solid state electronics, it mattereth little in the ultimate scheme of things that students high in dogmatism seem to have an advantage, for lo, almost all survivors receive certificates of completion. But in systems where achievement *is* related to who gets the best job, who gets the chance to go to college or to graduate school, the problem of the uninvited guest becomes a serious ethical issue. We hope that programmed instruction will be a real revolution in education, that it will help us reach the "Promised Land" where school drop-outs are reduced, where the level of knowledge is uniformly increased, and where achievement is independent of general mental ability or socio-cultural inequities. We may indeed find All of this to be true—but also find homogeneity of thought, conformity, and dogmatism; we may discover that we have educated a nation of walking computers.

It would indeed be premature to cry "Flood" from one drop of rain . . . and I certainly don't predict that a nation of walking computers is any more an inevitable concomitant of programmed instruction than I would claim that a nation of freely inquiring minds is the inevitable result of all conventional courses in all segments of this country. But I am wondering if these concerns are no less ours than theirs and I hope that I have rather suggested the challenge of developing programming techniques and methods of utilization which will invite wisdom to join the guest which we have already welcomed, knowledge.

PROGRAMMED INSTRUCTION OVER CLOSED CIRCUIT TELEVISION

Walter Dick

Walter Dick, reporting on research conducted by C. R. Carpenter and L. P. Greenhill at Pennsylvania State University, suggests that considerable variation can be introduced in the application of programmed instruction. In fact, even self-pacing is questioned. The use of programmed materials on closed circuit television was studied with results that open vast possibilities for training and education amplification.

The general purpose of this series of research studies was to investigate the possibilities of programming entire courses in mathematics and English grammar and to compare different methods and media, with special emphasis on closed-circuit television, for presenting programmed learning materials. In order to accomplish the objectives it was necessary to analyze especially the problems of pacing and individual and group conditions for the learning of programmed materials.

The research dealt specifically with the following subjects and problems: (1) A critical analysis of some assumptions of programmed learning and implications for adapting and using the new media; (2) The development of programmed materials for research purposes; (3) Experimental comparisons of external-pacing and individual-pacing for the study of programmed materials using different methods and media for presentations; (4) Comparisons of different rates of pacing and of individual and group conditions of study; (5) Comparisons of programmed televised presentations with (a) teaching machine presentations, and (b) instructor taught classes; (6) Studies of the effects of the minimum group of two students studying programs in comparison with individual study; and (7) Preliminary analyses of quantitative and verbal abilities of students relative to achievements using programmed courses, and of a personality factor relative to these study conditions.

The content areas selected for programming were introductory college algebra and English grammar. Special programmed courses were written, tested, revised, and adapted for presentation by teaching machines, programmed textbooks, film strips, and closed-circuit television. The completed algebra course consisted of 30 units of instruction; the course on English grammar contained 14 units. Appropriate and reliable tests of learning were also constructed. In general, these included tests on each unit of the programmed courses, mid-course tests, and end-of-course tests. Additional special purpose tests were also used in the studies.

Six separate controlled experiments were conducted. Four of these used the algebra program and two used the English grammar program. These experiments are briefly summarized: Experiment I, contemporary algebra course, made comparisons between several methods of presenting the programmed course—by teaching machines (self-paced), by programmed textbooks (self-paced), and by film strips (externally-paced). Performance of students receiving the programmed instruction was compared with that of students receiving direct instruction from an experienced teacher who covered the same topics by the lecture-discussion method.

Results showed no substantial differences in performance among the three programmed treatments as measured by the sum of students' scores on the unit-tests and their scores on a comprehensive end-of-course test. However, on the unit-tests the three programmed treatments combined produced significantly higher scores and lower variance than did the direct instruction by a good teacher. On the end-of-course test the means were not significantly different, but again the variance for the programmed treatments was significantly lower than that for the direct instruction.

Experiment II investigated the effects of varying the pacing of externally-paced programmed materials presented to groups of students by means of film strips. The initial times for each frame under the externally-paced conditions were based on the mean time taken for each frame by a sample group of students working on a self-paced schedule. In this experiment these base times were referred to as 100%, and the groups were paced frame-by-frame through the programmed course using times for each frame which corresponded to 80%, 90%, 100% and 110% of these base *rate* times.

Results showed that within this range of variations in external-pacing there were no significant differences in student performances or in attitudes toward programmed learning. Again, externally-paced and self-paced study conditions were found to be equally effective.

Experiment III involved a comparison between an externally-paced presentation of the programmed algebra course using closed-circuit television and a self-paced presentation using teaching machines. Results showed equivalent learning from both procedures as measured by summed unit-test scores and performance on mid-course and end-of-course tests.

Experiment IV investigated another aspect of the pacing and grouping problem—namely, the pairing of students for the study of programmed materials. In this experiment half of the students were randomly assigned to pairs; the remainder of the class worked as individuals. It was hypothesized that interaction among the students in each pair might facilitate learning, and provide more favorable motivation, including immediate social reinforcement, for programmed instruction.

Results showed that the performance of the students in the two treatments was equivalent on the unit-tests, the mid-course and the end-of-course tests. Further analysis of the results indicated that different learning abilities affected performance in the two different treatments. In the paired group, verbal ability accounted for a substantially higher proportion of the variance than did quantitative ability, whereas in the group that studied individually the reverse was found. Student attitudes toward programmed instruction were neutral and not significantly different for the two groups.

Experiment V which was conducted with the English grammar course comprised two studies with two different populations. One of these involved a comparison between a closed-circuit television (externally-paced) presentation and a teaching machine (self-paced) presentation.

The second study compared the performance of students taught by means of the programmed course presented over closed-circuit television, with that of students who were taught the same subject matter by an experienced instructor who used the lecture-discussion method.

The results showed that in each study there were no substantial differences in students' performances as a result of the different treatments they received. However, in the second study, student attitudes as measured by an attitude scale were significantly in favor of the instructor presentation.

Experiment VI was designed to investigate a further variation in conditions of learning which involved the pairing of a programmed course. A preliminary attempt was made to relate a personality characteristic of students to these conditions. In this experiment students were randomly assigned to two groups. They were paired on a personality variable of dominance-submissiveness. One group was paired so that each member of the pair was similar in this personality characteristic, i.e., the *most* dominant was paired with the *next* most dominant and so forth through the group. In the second group students were paired who were dissimilar on this variable. In this group students were ranked from most dominant to least dominant, and in a group of 30, number 1 was then paired with number 16 and so forth.

Results showed no significant differences in the learning of the two groups on the several tests that were used. However, there was some evidence that differential abilities and characteristics of the learners contributed to performance in the two groups.

It appears to be feasible to adapt and use those media which require externally-paced methods for presenting programmed materials to *relatively* homogeneous groups of learners without adversely affecting their achievement. Students of the populations sample have a relatively wide tolerance for variations in pacing-rate.

Closed-circuit television supplemented with printed materials can be used effectively for the presentation of programmed instructional materials to groups of students. This opens up possibilities for the wide distribution of programmed instruction, and for the integration of programmed sequences with lecture-demonstrations in televised instruction. The use of programmed materials on television, supplemented with printed response forms, provides an excellent means for obtaining active participation on the part of all learners and for providing immediate reinforcement of their responses. Results on the pairing of students to study programmed materials yield equal results as compared with individual study methods. The effects of this pairing procedure on motivation and attitudes are not yet conclusive and require further investigation.

Sampling of two content areas, mathematics and English grammar, yielded essentially the same results on all variables which were experimentally studied.

In general, this research challenges the classical assumptions that the best method of using programmed materials is that of self-pacing and individualized study. In other words, a learner's own speed may not be the optimum rate. The research shows some of the possibilities of using the new media and combinations of media with paced programs for instructing large numbers of students simultaneously in time-limited periods of instruction.

THE REQUEST FOR OVERT RESPONSES AS A FUNCTION OF RESPONSE RELEVANCE AND INFORMATION LEVEL*

Lewis D. Eigen and Stuart Margulies

The authors are concerned with the problem of overt (written) vs. covert (thinking) modes of response. They find that the necessity for overt responding may depend on the difficulty of the response. If the response is a relatively unlikely one, measured in terms of information available to the student at the time of response, the overt mode leads to better learning. However, if the response is easy, or if it is incidental to the teaching in the frame, the mode of responding is not a significant factor.

In several studies using programmed instructional material, students were instructed merely to "think" their responses instead of writing them. Results indicate that the students proceed through the program more rapidly than students who write their responses. Comparison of the post-test performance of students employing no written responses ("thought" or covert mode) with that of students who learned by making written (or overt) responses have yielded equivocal results. The present paper attempts to account for these divergent results by varying two response characteristics: the relevance of the required response to the material taught, and the information level of the required response.

Information level is a response characteristic related to level of difficulty, but more readily quantified objectively. Essentially, it is a measure of the "information" required to make a decision, and is computed as a function of the number of alternatives from which the decision is to be made. Information level was manipulated in the present study by constructing groups of three letter words of different informational value. The highest informational level was represented by words like ZBX, VRT, etc. in which three different consonants were combined. Since the first letter could be chosen from the 21 consonants of the alphabet, the second letter from the remaining 20 and the last letter from the remaining 19, the total information represented by words like ZBX is dependent on a discrimination between 21 x 20 x 19 choices. A lower informational level was obtained by selecting three letter words like SIJ. These consonant-vowel-consonant words represent less information because their structure is limited to 21 x 5 x 20 alternatives. A third category of words, CAT, FAT, BAT, MAT, HAT, etc., required far less information because selection could be limited to a very small number of words.

In the present studies the difference between the overt (written) response and the covert (unwritten) response was examined at each of the three information levels.

In addition to the overt-covert response distinction, a second response characteristic investigated is the relevance of the responses to the presented material. This may be referred to as the relevant-incidental learning variable. The example frame below is used to illustrate this dichotomy.

> Professor Fred Keller states that the formula for water is H_2O.
>
> Therefore, a molecule of water contains _____ atoms of hydrogen and _______ atoms of oxygen.

If we ask a post-test question dealing with the formula for water, we can regard this frame as one which elicits a relevant (or critical) response. If, on the other hand, the post-test question is structured to ask: "What is the first name of Professor Keller? ________," we can regard the example frame as providing only incidental learning, as measured by this post-test question.

The relevant-incidental variable might be called the "exposure only" versus "exposure plus indicated response" variable. The efficiency of relevant versus incidental learning can be examined by constructing two post-test questions following frames such as the example frame cited. One such question would call for the formula of water, while the second question would require Professor Keller's first name. If the students performed better on the former question, it could be concluded that relevant responses are more efficient. Conversely, if the latter question results in better student performance, this would be evidence of the greater efficiency of irrelevant responses.

Design

The plan of the study may be outlined as follows: each student is presented with an instruction booklet containing three items, each of which is presented four times. An item contains seven three-letter words, all seven of which are drawn from the same information level. The three items represent samples from the low, intermediate and high information levels. Thus one item contains seven three-letter low information words, one item contains seven three-letter intermediate information words, and the third item contains seven three-letter high information words.

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* "The authors wish to express their appreciation to the Carnegie Corporation of New York whose financial assistance made this study possible."

"A more comprehensive treatment of the data referred to in this paper appears in *The Journal of Programed Instruction,* Volume II, No. 1.

Each item requires the reader to respond to three of the seven words but not to the remaining four. Repetitions of the item differ somewhat in format and cueing but always require a response of the same three words. The first presentation of each item allows the reader to copy the correct response, but subsequent presentations demand a more uncued response. Each presentation of each item is made on a separate page and is always followed on the next page by the correct response. Since three items were each repeated four times, and each item was followed by the correct response, the instructional booklet used contained 24 pages.

A portion of the instructional sequence used is given below. It shows both a cued and relatively uncued presentation of the intermediate information level item, one cued presentation of the low information item and one uncued presentation of the high information item. A straight line indicates a new page.

Learn these nonsense words:
RIZ TUV RUD TIB KIG COJ YOL
Fill in the missing nonsense words:
RIZ TUV ______ ______ ______ COJ YOL

RIZ TUV *RUD TIB KIG* COJ YOL

RIZ TUV *** *** *** COJ YOL
The missing nonsense words are ______, ______
and ______.

RIZ TUV *RUD TIB KIG* COJ YOL

Learn these words:
BAT CAT FAT HAT MAT RAT SAT
*** *** *** *** *** ***
Fill in the missing words below:
BAT CAT ______ ______ ______ RAT SAT

BAT CAT *FAT HAT MAT* RAT SAT

ZBX VRT *** *** *** NSG YMQ
The missing groups are ______ ______ and ______.

ZBX VRT *MKL CFP DGJ* NSG YMQ

Three different instruction booklets were prepared. One introduced high information items first, one introduced intermediate items first, and one introduced low information items first. All contained 24 pages consisting of four presentations of each of three items plus the associated answers; only the order of presentation changed.

Upon conclusion of the 24 page booklet, students were asked to complete a post-test examination. The examination required students to fill in all of the seven words contained in each of the three items. (Twenty-one responses were required.) Percent correct on the three selected words in each item is compared to percent correct on the remaining four words. This provides a measure of relevant versus incidental learning (or synonymously, *exposure only* versus *exposure plus indicated response.*) This procedure is highly analogous to the application of separate post-test questions asking for *Professor Keller's first name* or *the formula for water* in the earlier example.

PROCEDURE

362 students were drawn from grades 7 and 8 of two New Paltz Junior High Schools. These served as experimental subjects in the study, and were randomly divided into two experimental groups. One group contained 179 students, and was required to write its re-

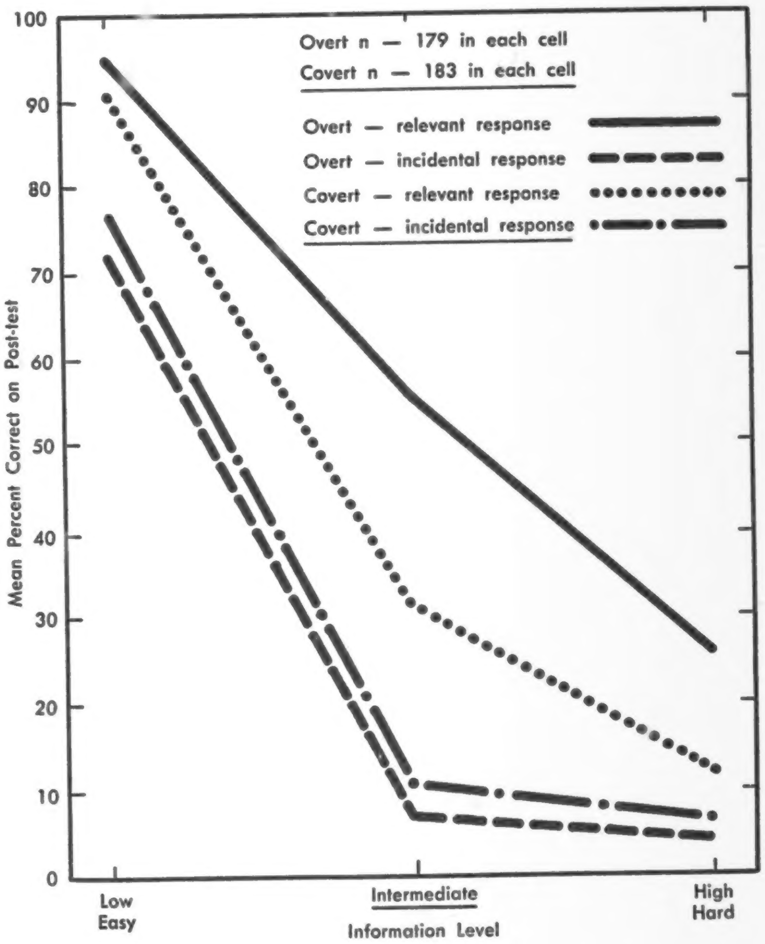

Figure 1

sponses (overt response mode) in instruction booklets. The second group contained 183 students and was required to think its responses (covert response mode). Except for the instruction which differentially instructed the two groups to "write" or "think" their responses, there was no other experimentally controlled difference between the groups. Both groups also were required to complete the same written post-test.

Students took the post-test as soon as they completed the instruction booklet. Typically subjects required less than 10 minutes to complete both the instruction booklet and the post-test.

Results

Figure 1 summarizes the results of the study. This data, when subjected to non-parametric analyses, supports the following conclusion.

(1) Performance scores decrease as informational level increases (or, almost equivalently, that students perform more poorly when the material is harder). This result is obtained whether the required response is covert or overt, relevant or irrelevant. (Friedman Analysis of Variance significant beyond the .001 level.)

(2) Student performance is superior with relevant (critical) responses than with incidental responses. This result holds for all three information levels whether the response be made overtly or covertly. (Sign test significant beyond the .001 level.)

(3) Overt responding yields more superior student performance than covert responding for intermediate and high information levels when the responses are relevant. (Mann-Whitley U Test is significant beyond the .0001 level.) No significant differences, however, were observed between overt and covert responding at the low information level or at the intermediate and high information levels when the responses were incidental.

IMPLICATIONS OF THE STUDY

This study supports Holland's view that in an instructional program responses should be relevant rather than incidental. It also suggests that the issue of overt versus covert responding can be resolved only as a function of the kind of material that is taught. It is entirely possible that with any given program certain responses should be made covertly and others, overtly, depending on the informational value of those responses at the time. Thus, frames of a program could be flagged as to which ones should be responded to overtly. Replication of this study with other materials is deemed quite important. While the materials in this study were not what might be described as "meaningful materials," it is important to ascertain whether the results will hold when meaningful, systematic bodies of content (as one might find in a school curriculum) are taught.

FILM AS A PROGRAM MEDIUM: TECHNICAL AND ECONOMIC CONSIDERATIONS

Gifford M. Mast

Gifford Mast analyzes the cost of film and a projector for individual programmed instruction presentation. The cost of individual hardware is currently high, but would be reduced substantially if the machines were mass produced. Raw film stock turns out to be cheaper than the paper needed to present the same number of frames. Major advantages of film appear to be its economical and flexible use in the short run, and for programs using color and illustrations.

The economics of the film as a programmed learning medium vs. paper, like almost all of the other problems in connection with programmed instruction, has no simple answer. Our calculations indicate that for information content, film can be a more economical medium than paper as well as more versatile. I don't think that film will replace paper in the broad field of education, but I do believe that use of film has greater possibilities than most people suppose. I shall try to show you some of the reason why I think so.

To have an economical film-type teaching machine, it might at first appear practical to use just a magnifier and, in fact, one well known company took that approach. But the simple fact is that you cannot get more than 2X or 3X magnification with a two-eyed magnifier without going to the relatively complex optics of a binocular microscope. With a one-eyed viewer you can use up to about 5X or 6X magnification, but who would think of doing programs with one eye! With only 2X or 3X magnification, I think it is safe to say that film is not attractive as a program medium because of cost.

If you abandon the magnifier type of viewer, you are then faced with a need for a projection device. And it was our conclusion that a projector with a 10X to 15X magnification was very practical for two reasons: (1) While you can get enough light through a piece of film to enlarge it much more than that and still have enough light to read your copy on the screen, the smaller the hole through which you put the necessary quantity of light, the more intense the light will have to be. The more intense the light, the more of it is converted to heat in a given area of film. Soon you are faced with the situation that you probably have experienced at some time with an 8mm or a 16mm projector: if the projector stops, the film burns to a crisp in a few seconds. The only way to prevent this is to have elaborate provisions for cooling the film; and (2) A low magnification does not require as costly lenses as high quality film work, nor as precise location of the film, but provides a good quality picture when viewed at normal reading distance.

Klaus and Lumsdaine have written a paper about the "economic realities" of teaching machines. It is their contention that a teaching machine has to be limited to the $12.50 to $25.00 bracket to be practical. When you compare what you require of a film-type teaching machine with other things on the market, you find you have something comparable to the typical $100 automatic slide projector you find in every camera store. One such projector we examined recently had an estimated $100,000 worth of tooling, and the manufacturer had produced over 250,000 such units in a year. There might be some question whether we are yet in that bracket of possible market for teaching machines, programs being the problem and as costly as they are. Therefore, I am going to assume, for the sake of this presentation, $150 to 300 is the range in which you might reasonably expect to find a film-type teaching machine being produced in low quantity.

All this talk about machines is because we can't use a film program without a machine and the cost of the machine is a significant factor in the problem of film vs. paper. While it may be difficult to prove by fully controlled, statistically valid methods, it is our belief that the right machine has a major advantage over books. As Dr. Douglas Porter stated, "It provides a more compelling presentation of Programmed Instruction than a book." Kaufman liked the "fascination" of the teaching machine and the fact that "they discourage the trainee from looking ahead, from going to places in a program other than where he should be." George Skroblus says, "a machine can prevent the trainee from looking ahead or skipping some of the material without proving he understands it," and states that, "for some adults, we've found the teaching machines have more appeal than a text, programmed or otherwise." Whatever you may say against machines is offset by the difficulty of trying to find your place in Dr. Skinner's book once you've laid it down!

Consider the *cost per class hour per student* as a unit to get a dollars and cents handle on things. The teacher we shall assume is, or should be, paid $9,000 per year. If you use an Iowa school year for an example, the teacher teaches about 900 hours and therefore, costs about $10 per class hour, not including any overhead. Let's assume the Talmud sanctified 25 pupils per class, so the cost is 40 cents per class hour per pupil for the teacher.

Let's see what the cost of the machine turns out to be, taking it as a $200 item, good for 5 years at an amortized cost of $40 per year. For safety, add in $10 per year for maintenance, making $50 per year the overall cost of the machine. If the machines are used as many hours as the teachers, for whom we assumed 900 actual teaching hours per year, the cost of the machine per hour will be 5.5 cents per student hour. Of course, a machine being a tireless mechanism might be used for more than 900 hours per year thus reducing that cost figure substantially.

We have estimated a cost to the school of about one cent per frame for copies of programs on films in cartridges for use in our teaching machine, this figure to represent a relatively small quantity production and to include the typical cost of programming. With substantial production we believe that this cost could go down possibly 50%. Assuming 100 frames per class hour, which we believe to be high, our student would be using 50 cents worth of film each class hour. But bear in mind this film is tested for 1,000 uses, and a super-conservative figure should be 100 uses, so the cost of providing film is down to 0.5 cents per student per class hour.

In a typical public school system, the cost of personnel is about 85% of the annual budget. One way of saving money is to increase the size of the class. In fact, if you could obtain just as effective instruction in a class of 50 with programmed instruction on a teaching machine as you do with 25 and no machine, you would have about 20 cents per student class hour with which to play.

The difference is demonstrated by asking: "How many students would we have to add to a class of 25 to save the entire cost of teaching machines and filmed programs?": (1) We have found the cost of a typical teacher is 40 cents per student with 25 students per class; (2) The cost of teaching machines and filmed programs we estimated at 6.0 cents per student hour; (3) Therefore, to offset the cost of using Programmed Instruction, the cost per student hour for the teacher must be reduced to 34 cents; and (4) Thus the number of students must be increased to 29:

$$N = \frac{.40}{.34} \times 25 = 29 \text{ students}$$

In other words, with the parameters we chose, an increase of less than 20% in class size offsets the entire cost of teaching machines and filmed programs.

Compare the cost of the programmed text with filmed programs. A hypothetical programmed text published in runs of about 50,000 copies consists of 3,000 frames, is a paper back selling for $3.00, or one-tenth cent per frame. Publishers have told me that the expected use of a text is 2.5 students. Consequently the cost per class hour per student is four cents. This figure of four cents per class hour per student compares with the six cents per class hour using the machine and filmed program. The former figure is based on a high production book, while the latter is on relatively low production, so it is reasonable to expect comparable production quantities to equalize these figures, or pass the advantage to film and machine.

Let us examine the basic medium itself: The cost of raw 35mm film stock is 1.6 cents per foot. Each foot of film provides screen area of projection with our machine, using 9X magnification, of 24 sq. in. x 32 = 776 sq. in.

Each sheet of 8½ x 11 paper provides 92.5 square inches. Disregarding the fact that ample margins generally must be provided on the paper but have already been deducted in our film calculation, we will say each sheet is equivalent to 4 frames, or 96 square inches on our screen. Paper (20# mimeo) costs in quantity about $1.10 per ream (500 sheets) or 0.22 cents per sheet. The equivalent raw film area is ⅛ of a foot of 35mm film costing 0.2 cents. Raw film costs less than raw paper.

There is one particular area where film offers outstanding cost advantages. This is the area of the short-run program of which you may want 5 to 25 copies for testing and validation or 100 copies for industrial training, or even a few thousand copies of a national training program, or of a program at an advanced scholastic level.

There the film eliminates: (1) Retyping on stencils or offset masters or typesetting, and (2) More important still, it eliminates the extra proof reading, which may cost more than the copying or typesetting itself. It makes possible the economical use of illustrations, whether they be line drawings, existing half-tones, or original photos.

Digressing, in a sense, from strictly economic considerations, let us point out the great freedom in the use of illustrations that film provides the programmer, even during the testing and validation phase of his work. And if one picture is worth 1,000 words, we're going to get a lot of "yakkity-yak" out of some programs by using film as our medium!

The possibility of using color, even in short run programs, is important. With a printed program, color plates can be an enormous cost per copy. With film, the raw print film costs 3.6 cents per foot instead of 1.6 cents. Think what this can mean to sophisticated and therefore relatively short run programs for medicine, botany, zoology, physiology, crystal structure, and art. The raw material cost for 10 hours (800 frames) of full color program print is less than 60 cents more than for the same amount of program in black and white. This added material cost provides, not just an occasional illustration in color, but the possibility of color in every frame and answer.

Some one has said to us: "We aren't ready to film these programs yet because they haven't been fully validated." He is wrong. One of the easiest places to effect an economy in program *preparation* is through taking advantage of what you can do with film and a projection type teaching machine.

In summary, I think we can say that the economic side of using film as a programmed instruction medium is characterized by these points: (1) The machine is a substantial cost factor but will probably be small compared to the cost of programming itself except for high consumption programs; (2) The cost of raw film as compared to paper is more or less a standoff but can be expected to show a greater advantage for film as the technology develops; and (3) Major advantages of film appear at this time to be its economy especially in short runs, and its flexibility in permitting the use of color and illustrations.

On the general side, we can say that film offers the programmer simplified mechanics and a freedom in the use of illustration and color. In fact, we are still looking for the program that really challenges the full versatility of film.

INDIVIDUAL DIFFERENCES IN MENTAL ALERTNESS AND IMPLICATIONS FOR THE SCHEDULING OF PROGRAMMED INSTRUCTION

Wallace Bloom and John Pierce-Jones

Learning theorists have recognized that there are diurnal variations in vigilance that affect learning. Self-ratings on mental alertness showed substantial variations and, on a time continuum, correlated positively with adjacent ratings and negatively with those further away. The period from noon to 6:00 PM was most frequently reported as below average. Effectiveness of programmed instruction might be increased by scheduling it with due consideration of an individual's diurnal pattern. There is need for further research, particularly involving the scheduling of programmed instruction on an individual basis, to determine the full extent to which an individual's diurnal variations may be a systematic rather than a random source of variance in human learning.

By habitually observing socially determined schedules, specifying the hours for work, play, meals, and sleep, man has developed a dinural rhythm. Marsh (1906) reported that diurnal rhythm imposed a corresponding periodic character on human efficiency. Kleitman (1949) found that efficiency of performance and degree of alertness seemed to conform to a rise and fall of body temperature. Pillsbury's (1903) study of attention waves indicated there was fluctuation in their total length with time of day, and that attention waves corresponded in length with the Traub Hering wave of blood pressure. A twenty year study of workers in Munich, Germany (Lehman, 1954), found variation in the amount of adrenalin in the subjects' blood, the curve for which repeated itself even on non-working days. Renal excretory activity (Mills, Thomas, and Yates, 1954), body temperature (Kleitman, et al., 1938; Carlson and Johnson, 1937; DuBois, 1948; Murray, Williams and Lubin, 1958; Winslow and Herrington, 1949; Mellete, et al., 1951) water, chloride, and sodium excretions (Lewis and Lobban, 1957) in subjects all showed consistent diurnal variations. As stated by Pierach (1955), "No organ or organ system is exempt from the twenty-four hour rhythm in its function."

Thomson (1952) used three subjects to study the relationship of variation in skin temperature to general fatigue. He found that individual differences were pronounced in respect to temperature recordings and verbal reports of fatigue.

Williams (1956) reported that body temperature, as determined orally, undergoes diurnal variations but, if a series of well young men are tested at the same time of day, considerable variation is observed. The temperatures of 276 medical students between 8:00 and 9:00 A.M. varied from 96.6° to 99.4° F. He concluded that diurnal variations are related to sleep patterns which are often distinctive, sometimes easily modified and sometimes not.

From 1912 through 1931, Bjerner, Holm, and Swenson (1955) studied the errors made in entering figures related to gas production in ledgers of a large Swedish gas works in which 3 weekly rotating shifts were employed. The greatest number of errors occurred consistently at 3:00 A.M. regardless of which shift was on duty. Variations in errors were the same the last night of the week as on the first, so they concluded that one week was not enough to change the general pattern of the workers' diurnal variations. There were neither winter vs. summer variations, nor 1915-1919 vs. 1920-1924 changes. Bjerner, Swenson (1953) found the highs on error curves were not due to physical fatigue and that three different groups failed to adjust to changing shifts.

Adams and Chiles (1961) subjected two B-52 combat crews to confinement for 15 days in a simulated space craft on an around-the-clock schedule of 4 hours duty and 2 hours rest. The diurnal variations for both performance and psychophysiological measures persisted throughout the 15 day period in spite of the subjects being removed from the usual day-night routine and environmental changes.

Mackworth (1956) was concerned with the real psychological event that people failed to notice and act upon a signal that they were quite able to detect. He conceived the measurable determinant of this psychological event as *VIGILANCE*, "a state of readiness to detect and respond to certain specified small changes, occurring at random time intervals in the external environment."

Deese (1955) stated that "largely due to the influence of Mackworth the words *ATTENTION* and *SET* have been replaced by the term *VIGILANCE*". The concept of *VIGILANCE* conforms to the requirements of a concept in that it is "an abstraction from observed events . . . a shorthand representation of a number of facts". A subject may customarily have a low state of vigilance at a particular time of day, without it being caused by continuous work.

Head (1923) contended that if the level of vigilance is lowered, specific mental aptitudes dies out as if the voltage falls. "The more highly differentiated the act, the greater the degree of vigilance does it require." Oswald (1962) applied this to the cerebral cortex and said " . . . That the higher, within limits, the level of cortical vigilance in wakefulness (the level being dependent on the constantly fluctuating ascending facilitation from the reticular formation) the more complex data that can be dealt with." He believed that our future understanding of the nature of attention will show it to be closely related to those mechanisms governing cerebral vigilance which are manifest in sleeping and wakefulness.

It is appropriate to give brief consideration to the positions of learning theorists regarding vigilance and diurnal variation. Thorndike's (1913) Law of Readiness makes concession to the existence of the organism and variation in its state of vigilance. Hull's systematic behavior theory contains several variables that are functionally related to diurnal variations in vigilance. In Hull's own words:

> XVII the "constant" numerical values appearing in equations representing primary molar behavioral laws vary from species to species, from individual to individual, and *from some physiological states to others in the same individuals at different times.* All quite apart from the factor of behavioral oscillation (sor). (Hull, 1951).

Freud assigned anxiety production to the ego and the normal habitual levels could be considered as vigilance. Taylor used this concept to create an anxiety scale, and found that the more anxious subjects were conditioned more readily than less anxious ones (Hilgard, 1956). This also holds true of vigilance when within optimal limits.

According to Skinner (1957) cyclic changes during the waking hours, which may or may not be correlated with ingestion or other scheduled activities of the individual, are seen in both verbal and non-verbal behavior. McGeoch (1942) considered diurnal variation of vigilance as a source of uncontrolled residual variability. Hebb (1961) fully supported the existence of diurnal variations of vigilance and used the terms, "cyclical changes in excitability."

This investigation concerned college undergraduates utilizing programmed instruction materials. The specific purpose of the study was to describe the students patterns of self-reported diurnal fluctuations of mental alertness and efficiency.

The subjects were 201 University of Texas undergraduates (male and female) taking a course in the psychology of adolescence by means of programmed instruction. Each subject recorded his evaluation of his own mental alertness and efficiency for each of the seven 2-hour periods starting at 8:00 A.M. as: (1) much below my usual level of performance, (2) a little below my usual level, (3) my average level, (4) a little better than my average, and (5) my peak performance. (The rating form is shown as Figure 1.)

Name__________________; __________________
Family First
Course &
Section: __________________Code No: ________

Self-Rating of Level of Mental Alertness and Efficiency at Various Times

This form is to record your own evaluation of your own mental alertness and efficiency at various times of the day. Consider how well you believe you study, organize and perform academic activities. Make *ONE* check mark for each two hour period.

Rating Scale

1. Much below my usual level of performance. (I find it hard to get started to concentrate; or get results in the usual period of time.)
2. A little below my usual level. (I must make an extra effort to keep my attention focused or it takes a little longer than usual to perform the task.)
3. Function at about my average level.
4. Doing a little better than my average. (Easier to keep alert in class and accomplish assignments.)
5. My peak performance. (Work is performed most easily and quickly.)

Note: More than one period may be checked for each of the above ratings but *each of the five should be checked* somewhere in the time period.

The results of the study are shown in Tables 1 and 2. Table 1 shows that comparatively few individuals considered themselves as performing above their average during the hours of noon to 6:00 P.M. This, along with the evidence that more than half believed they

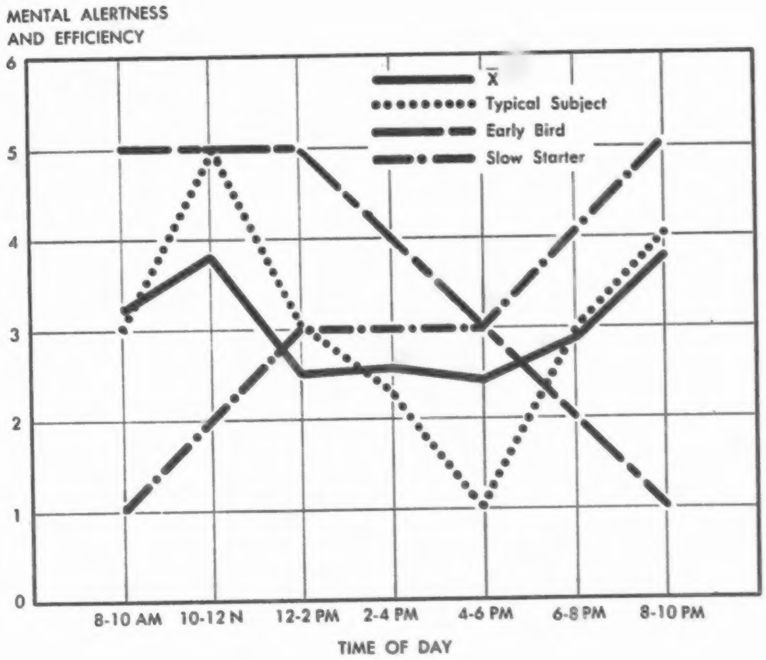

Table 1

College Undergraduates, Self Appraisal of Mental Alertness and Efficiency at Different Times of the Day: Spring 1962

Lowest			*Average*			*Highest*	
Time	*1*	*2*	*3*	*4*	*5*	*X*	*0*
8-10 A.M.	46	29	30	41	55	3.15	1.53
10-12 N.	2	29	39	57	74	3.66	1.10
12-2 P.M.	51	43	71	29	7	2.49	1.12
2-4 P.M.	30	59	68	31	13	2.69	1.10
4-6 P.M.	57	60	48	25	11	2.37	1.18
6-8 P.M.	39	42	44	44	32	2.94	1.36
8-10 P.M.	22	17	34	48	60	3.73	1.35

N - 261

were below their average during this same period, appears particularly relevant to the scheduling of programmed instruction. Within the range of administrative restrictions, the uniqueness of individual patterns, such as the "Early Bird" and the "Slow Starter" whose diurnal patterns are shown in Figure 2, probably should be taken into account when preparing individual schedules. Of course, such a suggestion as this takes it for granted that Ss rate their efficiency with better than chance validity and that learning and performance variance is reliably associated with such self-ratings by Ss. In this connection, it can be noted that Welford, Brown, and Gabb (1950) found a relationship between self-rated fatigue and complex task performance, and Fraser and Samuel (1956) found a significant association between self-rated fatigue and vigilance. Shaw's (1954) work with air traffic controllers did not, however, produce confirming results.

Subjects' ratings for each period were correlated with their ratings for each of the other periods. The results are shown in Table 2. In general, the findings indicated that the self-appraisal ratings at a specified period were positively correlated with the adjacent periods but negatively with all other periods. This confirmed the existence of a systematic rhythm rather than a random pattern.

Examination of individual reports showed, as would be expected, many typical patterns similar to the average trends. Predictably, of course, a few "early birds" started the day at a high level and decreased continually after noon, and a few "late starters" began the day at a low level, reached their average mental alertness in the afternoon, and were apparently highest in the evening. (See Table 2.) This is consistent with the findings of Freeman and Hevland (1934) who reviewed 69 research reports on diurnal variations in performance, found there was no single pattern, and classified the patterns into four general categories. In 34 reports on mental performance, they found: 12 Type I, continuous rise in performance; 12 Type II, continuous fall in performance; 5 Type III, morning rise, afternoon fall; and 5 Type IV, morning fall, afternoon rise. These four types discovered in their review

Table 2

Correlation of Changes in Self Appraisal Ratings of Mental Alertness and Efficiency at Different Times of the Day

	8-10AM	*10-12N*	*12-2PM*	*2-4PM*	*4-6PM*	*6-8PM*	*8-10PM*
8-10 A.M.		.1787*	−.1766*	−.2924**	−.3413**	−.2767**	−.3957**
10-12 N.			.0820	−.1563*	−.2327**	−.1728*	−.2376**
12-2 P.M.				.1759*	−.0887	−.2591**	−.2088**
2-4 P.M.					−.1883**	−.1793*	−.1969*
4-6 P.M.						.0607	.0531
6-8 P.M.							.2689**
8-10 P.M.							

Note. N = 201
*P = .05 **P = .01

5

by Freeman and Hevland, may have been due in part to the selection of subjects from one socially determined schedule by some researchers and of subjects from other schedules by other researchers.

The probable importance of scheduling for programmed instruction in relation to an individual's diurnal pattern can be illustrated by an actual example. One male subject reported that after he had filled out the self-rating form, he had thought further about his own daily variations in mental alertness. His hours in the programmed instruction laboratory were self-selected and he customarily came in at 1:00 P.M. and studied for an hour. Invariably he had *not* completed a lesson (approximately 72 frames) in his hour and had to file it in the "pending drawer" and complete the last frames at his next laboratory period. It usually took him six periods to complete five lessons. One morning when he made up a missed period, however, he completed the entire lesson. Thereafter he attended the laboratory in the morning, finished a lesson each hour, and often had time for a cigarette or soft drink before his next class.

WHAT SHOULD BE PROGRAMMED FOR TELEVISION?

George L. Gropper

George Gropper analyzes the capability of the television medium to meet the stimulus-response requirements of various subject matters. He concludes that television is uniquely qualified for certain types of visual presentations and that optimum use will be made of the medium if restricted to such presentations.

During the past few years, programming techniques have been adapted for use in instructional television. 1961) in which, among other more analytic findings, Arthur Lumsdaine and I have reported on U. S. Office of Education Title VII research (Gropper & Lumsdaine, students who responded to programmed sequences out-performed those who merely viewed conventional lessons. At State Park, Pennsylvania, Carpenter and Greenhill are completing research in which programming techniques have also been adapted to television. In studies currently in progress (Gropper, 1962) I have been engaged in applying programming techniques to the presentation of science demonstrations. Does it make sense to apply to group instruction programming techniques and methods developed for individual instruction and if so, how?

If by programming we merely mean exercising explicit control over student learning behavior, the question that should be asked is not "should TV be programmed?" but rather, "*what* should be programmed for TV." There can be little question about the desirability of controlling the learning process as closely and as explicitly as possible, whether students are learning from teachers or teaching machines or texts or even television. There can be some question as to whether some subject matters can more effectively be taught by means of one medium rather than by means of another. I would like to suggest some guidelines for deciding what are appropriate types of subject matters for presentation over television.

We have all in varying degrees paid some measure of lip service to the systems approach to the problems of training and education. We have tended to say, let us choose each medium for the job it can do best, whether it is a teacher, a programmed text, or a teaching machine. But it has not been easy to determine exactly what television can do best. I would like to suggest two well known criteria which will help us make this decision: cost and achievement. Under cost we may include such things as time, administrative convenience, and human and physical resources. *Achievement* is the end product of the efforts of both those being instructed and those providing the instruction. In terms of both criteria the functional capabilities of instructional television can be assessed.

Cost

Instructional television is an extremely expensive medium. The costs of planning, preparing, producing, transcribing, and transmitting lessons are quite high. If we follow current practice of not accepting lesson sequences until after pre-testing and revising so that they might reach some prescribed standard, the costs of televised instruction can conceivably double, triple, or multiply even more. But the ink in the ledger is not all red. The traditional argument for TV is that many students can be reached at the same time. When costs are prorated over many students, per student costs may in fact be quite low. The critical question thus becomes whether the many students reached by television are learning as effectively as possible.

Achievement

One of the major problems encountered in Educational Television is the problem of individual difference or student capability. The results of studies which we have done at the American Institute for Research, working jointly with Metropolitan Pittsburgh Educational Television Station, WQED, in Pittsburgh, Pennsylvania, have shown that there are difficulties in accommodating individual differences when providing instruction for heterogeneous groups. One attack on this problem, which we are currently pursuing, is to explore the possibilities of creating homogeneous groupings based on learning rates and of adapting instruction suitable for these groupings. It is hypothesized that in this way higher levels of achievement will be realized.

What are the characteristics of TV, and of other media, which influence the effectiveness of instruction, and what are the characteristics of subject matter content which interact with characteristics of the instructional process? Subject matter areas differ, of course, with respect to the types of stimulus materials which are integral to them. Physics, for example, involves both visual and verbal stimulus materials. History, on the other hand, can more usually be taught with purely verbal materials. The visual presentations in physics are likely to be both static and dynamic. Visual presentations in botany, on the other hand, are more apt to be purely static. Similar differences occur in nonacademic training areas. Visual tracking of moving objects involves transient stimuli. The assembly or disassembly of objects typically involves stimuli which are static and also dynamic.

Media differ in both their display and response capabilities. They vary in the complexity of their capabilities for displaying stimulus materials. Some media, such as film or TV, have a highly complex capability of displaying both visual and auditory stimuli of great range and variety. Other media, such as a textbook, have much less flexible and much less varied capabilities for presenting the range of relevant stimuli required by diverse subject matters. Media can be ordered in terms of the complexity of these capabilities for displaying relevant subject matter stimuli. The medium which is used to create the learning opportunity thus must have both the appropriate display and response capability, so that students or trainees be permitted to practice relevant reponses in their presence. If the relevant stimuli are transient, the medium should be capable of displaying them, e.g. films or TV. If the stimuli are static, the medium should be similarly capable of displaying them which is a much less difficult requirement to meet.

Media can also be ordered in terms of their capabilities for controlling the instructional process, such as the ability to control the amount, timing, and duration of displayed stimulus materials. Film and TV, for example, differ from teaching machines or textbooks with respect to the rate at which material is presented and with respect to who controls the rate. These factors related to the explicit control over stimulus display have a significant bearing on achievement to the extent that they facilitate or interfere with the practice of *correct* responses.

In the case of television, there is a highly flexible visual and auditory capability. Precise control over amount and type of material is possible. It is possible to arrange conditions such that responses are prompted only in the presence of specified stimuli. These conditions favor the practice of correct responses; others do not. The fixed-pace character of films and television can interfere with the capacity of the stimulus materials to cue correct responses. There is no self-pacing capability which might interact with the specially prepared stimulus materials in allowing and indeed encouraging correct responding. The same specially prepared stimulus which can successfully cue correct responding when the student is allowed as much time as he needs, may be inadequate for the same purpose if an external time limit is imposed on the student. It is here that the problem of individual differences becomes serious.

It is entirely possible to alter stimulus materials or to allow sufficient time, determined empirically, so that few or no students will be left behind; but the greater the heterogeneity of the group, the more likely it is that this lowest common denominator will have its inherent drawbacks. Other approaches are possible. Thus, not only will time be varied, but also the content. For example, strength of cueing or amount of practice or review might differ for fast and slow learners. This is an approach we are currently investigating, using learning time which is characteristic of individuals as a basis for sorting them into homogeneous groups. Of course, when one is dealing with a relatively homogeneous group to begin with and when in addition the group is a high-ability level group, say a college population, a single grouping may be quite sufficient. The median time required may prove successful as in reports from research at Pennsylvania State University.

It was pointed out earlier, in connection with subject matter content, that media can be ordered with respect to the complexity of their capabilities for presenting stimuli relevant to the subject matter, relevant stimuli to which students may be encouraged to practice relevant responses. Here, too, in connection with the instructional process, we can order media in terms of their capacity to present stimuli in such a way as to facilitate correct responding. Television was ranked quite high with respect to its capacity to display relevant stimuli to which relevant responses might be made. In the case of the instructional process, because of its fixed-pace character, it may have to be ranked relatively low with respect to its capacity to prompt correct responding. A third consideration or criterion for evaluating media is the logistical or economic one. Thus media may be ranked in terms of three criteria: (a) capability of displaying stimuli; (b) capability of controlling condition of display; and (c) cost.

In deciding which medium to use for a particular subject matter, it would appear that one ought to start with the criterion having to do with the capacity of a medium to display relevant stimuli to which appropriate responses can be made. A pragmatic approach would call for the selection of the medium with the minimum capability to do the job. The minimum is suggested because it would leave more complex media available for more important jobs, and it would also tend to be the most economical approach, since complexity of capability and cost are likely to be directly related. The second consideration might be the capacity of the medium to facilitate correct responding. When on the basis of the first criterion more than one medium might do the job, media can then be judged in terms of the second criterion, namely control over the instructional process. Over and above correct responding, other control features such as response provisions, safeguards against such things as cheating, etc., would be considered. Cost considerations, the third criterion, would enter only after these achievement considerations had been settled. Judgments about media found equally capable in terms of the first two achievement criteria would be based finally on money considerations.

What I have been describing, of course, is the optimum way of making decisions about media utilization. In any practical situation, all three sets of criteria we have been discussing are likely to be considered jointly. Compromises and trade-offs are likely to be found necessary for a variety of reasons. These might include: the desire to make full use of media already paid for and available rather than acquiring new media facilities; the administrative convenience made possible through the use of one medium rather than another. Compromises in media selection may result in under- or over-utilization of a medium. A medium is under-utilized when it is used to display stimuli which a medium of less complex capabilities can handle. It is capable of a far more complex job. For example, television is under-utilized when it is used to present printed material which could be presented equally well or better in a textbook, teaching machine, or on slides. If available and paid for, and if there is the desire to make fuller use of the more complex medium, it is possible to use the more-complex-than-necessary medium for the simpler job. It may be used, however, only so long as it brings with it no liabilities. In the case of television, while it is fully capable of displaying printed materials, it nevertheless imposes a number of individual differences problems. To the extent that these cannot be offset, the medium would not only be under-utilized, it would also bring with it serious liabilities. When a medium brings with it no such liabilities, its capabilities may be under-utilized but they may still provide effective instruction.

Over-utilization arises when a medium of simple capabilities is expected to do a job requiring far more complex capabilities. The use of a succession of slides to try to simulate motion or transient stimuli, which can only be effectively displayed by means of film or TV, is an example of over-utilization. In contrast to under-utilization (which brings with it no liabilities), over-utilization appears to be the far more serious problem to the educator because it is likely to be more costly, in terms of unacceptable standards of achievement, than are compromises which err on the side of under-utilization.

Using TV as a kind of group teaching machine for presenting strictly verbal material would appear to be a waste of the medium's far more complex capabilities. It would constitute, it seems to me, under-utilization. It may also not be adequate to the job of accommodating individual differences, at least not at an economical cost. The creation of homogeneous sub-groupings and separate presentations for them will increase per-student costs. But TV may be required to do an effective job in presenting dynamic or transient stimuli in a way that less complex media cannot. It can present science demonstrations, either to teach facts and concepts or to teach laboratory procedures, which would not adequately be handled by an individual teaching machine of far less complex capability. Television would appear to be suitable for training involving visual discriminations about transient stimuli (e.g. radar scopes, identification of moving objects, landing a plane, and steering vehicles). The nature of the subject matter stimuli determines what is the most appropriate medium.

If, as suggested earlier, what we mean by programming is the control over learning behavior, then the "what" of "what should be programmed for television" are visual presentations. They are the visual presentations which are required by the subject matter and which cannot be effectively displayed by other media.

While it appears highly desirable that responses to visual presentations be made under the explicit control of specified parts of a presentation and that they be made actively, as they often are to verbal stimulus materials, this has not been typically the case in filmed or televised instruction. It is feasible to attempt to require active responding to visual stimuli whether the responses consist of visual discriminations, verbal responses, or non-verbal motor responses. While responses other than those being controlled may also be made, which are usually referred to as implicit responses, to the extent that stimuli and responses can be specified, greater control will be exercised over the learning process.

In the experiment mentioned at the beginning of this paper (Gropper, 1962), an entirely visual lesson on Archimedes' Law was programmed for television presentation. The students were encouraged to make visual discriminations about the events of a demonstration illustrating the concepts covered by Archimedes' Law. Students made discriminations about scale readings for objects weighed in and out of water; about amounts of water displaced by objects weighed in and out of water; about amounts of water displaced by objects of differing size; about the magnitude of buoyant force for objects displacing varying amounts of water; about the magnitude of the apparent loss of weight for objects of varying size; and finally, about the inter-relationships among all these phenomena.

The demonstration was broken down into small steps, sequenced, and organized in such a way as to prepare students to make the relevant discriminations correctly. Students actively made the discriminations by selecting the correct answer from appropriate choices. The demonstration was pre-tested and revised until it was relatively error free. On the basis of this lesson students were ultimately able to answer both verbal and pictorial achievement test items. Equally as important as demonstrating the possibility of teaching essentially verbal material by non-verbal visual means is the demonstration that it is possible to control student responses during visual presentations. The more precise and extensive this control is the less likely are adventitious factors to intrude.

Static or dynamic visuals may serve a number of functions in the control of student responses. These have been described elsewhere in detail (Gropper, 1963) and will be described only briefly here. Visual displays may be used to cue responses in any of the modes we have described earlier. In this capacity visuals which already control such responses are likely to be selected. Similarly, such visuals may also be used to provide confirmation for responses, i.e., responses predicting events or responses indicating which of several static visuals is the one appropriate to a given occasion or situation. When the visual is one of a class of visuals to which the student is expected to respond, it may also serve as an example used to facilitate the acquisition of a generalized response. Understanding of a principle is thus built up through the use of a series of visual examples.

In serving a cue, reinforcement, or example function, visuals rather than words are used for one of two reasons. A visual may be relevant to and an integral part of the subject matter. It therefore appears in the criterion situation and the student is expected to respond appropriately to it. Experiments in science are a good example. The student, following instruction, is often expected to observe, describe, or interpret physical events. The visually perceived events are criterion events. Visuals used in instruction may be identical to or highly similar to those found in the criterion situations. These visuals may be called criterion visuals. The object of instruction is to bring appropriate responses under their control.

Other visuals can be used in the learning situation despite the fact that they do not occur in the criterion situation. They are used primarily because the responses that we wish the student to practice are already under their control. The visuals are therefore used to cue or prompt these responses so they may be brought under the control of other stimuli, usually verbal stimuli. For example, graphs and charts can be used to cue responses which may then be brought under the control of other stimuli. The graphs or charts are not typically found in the criterion situations. Such visuals may be called intermediary visuals, denoting their instrumental and temporary use.

Intermediary stimuli appear to hold promise as being the visual counterpart of familiar verbal stimuli already in the student's repertory. We use familiar words, ideas, or concepts to prompt responses which prepare the student to learn new responses. Students can already respond meaningfully to many properties of visual materials. We can, therefore, use such visually perceived stimuli as lines, boxes, arrows, graphs, etc., to prompt responses, just as familiar words prompt responses, so that their control can be transferred to other stimuli. Familiar visual materials may thus be added to familiar words as further tools in shaping the acquisition of new behavior.

Both film and TV possess highly rich and flexible visual capabilities, not to mention audio capabilities. These capabilities can be used instrumentally to control the conditions under which learning takes place. This might include the control over the amount and timing of the presentation of stimulus materials; and control over the opportunities for responding in the presence of particular stimuli and not others. These same capabilities may also be employed to exercise control over the content presented. They can be used to present stimuli relevant to a subject matter which other media cannot present. They can be used to present criterion visual stimuli and intermediary visual stimuli which are to control the practice of responses which, as dictated by instructional objectives, are relevant and correct. If we seek to use these visual materials presented by film or TV in as systematic a fashion as we have verbal material presented by means of other media, we stand a good chance of finding a cornucopia of valuable tools, as yet minimally taken advantage of, to be used in our new and expanding instructional technology.

Television ought to be used for those subject matters where relevant stimuli are visual and are dynamic or transient. We accept some of the liabilities of the medium imposed by its fixed-pace character. For the purposes of accommodating individual differences, we may settle for an instructional sequence that is too long for the fast learners but which is needed by the slow learners. In terms of time we have not been as efficient as possible, but in terms of achievement we are likely to be highly efficient. We reach this kind of achievement efficiency because of television's capability for displaying relevant visual stimuli. Used in this way, television is the visual medium it has so often been described to be.

PROBLEMS AND ISSUES IN THE PUBLISHING OF PROGRAMMED MATERIALS

John R. Everett

John Everett states that a publisher is clearly at fault if a teacher says one of his programs fails to teach. It is the publisher's job to insure the quality of his product by conducting extensive field tests. The testing and consequent revisions are quite costly, and will raise the price of a program above that of a textbook. But the increased cost is well worth the increased effectiveness of the product.

As far as we know, the kind of printing that we have known in the West had its origins in the middle of the 15th century in Mainz, Germany. Since that time Western man has enjoyed the enormous benefits of ideas and facts flowing from mind to mind by way of the printed page. It is fitting that those interested in the flow of ideas and facts recognize that mass production started with Gutenberg and not with Henry Ford and that we attempted efficiently to satisfy the mind long before we applied the efficiency of manufacturing interchangeable parts to the task of satisfying the desire for movement.

From the time of Gutenberg to just a few years ago the format for knowledge presentation in book form changed very little. A glance at one of the illuminated pages from the Gutenberg Bible indicates that the words are strung together in sentences, groups of sentences are divided into paragraphs, illustrations are scattered around the page, and color is lavishly used in the illustrations. There have been many changes in the technique of printing since 1454, but most of the books used today still divide words into sentences, sentences into paragraphs, paragraphs into pages, and, in many cases, color the illustrations.

The way in which knowledge was presented on the first printed pages has an ancient history, stretching far back into the years before movable type was invented. The author hoped he used words that conveyed his meanings and his craftmanship was judged by his skill in using grammatical conventions and his ability to select the right word. Since our earliest written alphabet language, perhaps between 1000 and 600 B.C., our grammars have been refined and our dictionaries have given increasingly precise meanings. But the basic form of written communication has remained the same, with an author hoping that the meanings he intends are the meanings his readers receive.

The purpose of this excursion into history is to indicate just how radical is the change being created by programmed material. The printing press is the same, but the organizational pattern of the page is truly different; the words are in sentences, but rarely are they in paragraphs; the lonely author writing in the hope that his words mean what he thinks they mean is replaced by a group of writers constantly testing their meanings on groups of their readers.

Now, how does this affect publishing?

In the past the task of a publisher was to find an authoritative author, give him an advance (small as possible), wait for a manuscript, hand it to an editor (as underpaid as possible), let the editor clean up the grammar and the organization, send the copy to the printer, proofread it, and shower as many copies on the market as his sales force thought they could sell. The publisher stood between the author and printer, and the printer and the market. Very often he has viewed himself as the amoral midwife who cares not how the child is conceived, but whose only task it is to see that the baby lives.

The publication of programmed materials requires that a publisher deal with not one author, but with a whole host of experts such as programmers, subject matter people and test subjects before he ever sees a manuscript. He must satisfy himself that the subject matter people know their business and he must know that the testing procedure keeps the programmers in line. And even after he has done all of this, he still is not sure when he gets the completed manuscript that it is a valid teaching instrument for 5,000 school children. The publisher must go back again to his customers and test again on a large sample of school children if it is text material.

The standard traditional text book always had two other groups, the teachers and students, ready to accept blame for non-learning. Both the publishers and the authors would loudly proclaim that they had an excellent book, but the teachers misused it and the poor students suffered. Since the teachers couldn't accept such blame without some kind of answer they would counter with the statement that the book was fine, but not written for their *special* students. And if all else failed, everyone would turn on the student and say that he obviously didn't work hard enough and that the modern generation didn't have any motivation anyway.

The underlying assumption of programmed instructional materials is that if the student doesn't learn the fault lies directly with the program and the teacher; and in many ways, more with the program than the teacher. If the subject matter is sound and the programming has been skillfully done, neither student nor teacher can be blamed for a lack of learning. The publisher doesn't even have a single author to blame. If the publisher has not had his program tested and validated before he releases it, there is only one final resting place for the cause of the poor results. Programmed instructional materials have finally broken the happy circle which made it possible for adults to be guiltless when children failed to learn. And, even more, teachers can now look publishers squarely in the eye and say, "I care not for your illustrious board of editors and for the fine names you place on your covers, the stuff we bought just plain doesn't work!"

It is my guess that those who use programmed learning materials are going to have to learn how to evaluate properly the claims of publishers regarding their testing procedures and results. As far as I know there isn't a person alive who can sit down with a program and tell you within a few hours whether it is a good program or a bad one, and whether it will teach or not. There are countless subject matter people who can pick up a traditional textbook and in very short order give a reasonably sound judgment regarding the adequacy of its coverage, the elegance of its style, and the soundness of its interpretation. We have lived with the traditional format so long that we know what to look for and we know where the guide lines are and where they lead.

The genius of a good program is that it is so constructed as to teach certain things about the subject to someone who knows nothing about it. All an expert in the subject can do is to tell you that the coverage claimed is actually on the pages. He cannot tell you that the program will teach. Nor can he tell you whom it will teach. An experienced programmer can tell you what he thinks the program *might* teach, but he cannot tell you that it *will* teach. Only a fairly good sample of students who have actually taken the program and who have actually been tested for comprehension can tell you if the program teaches. Both publishers and the users of programmed materials must become much more sophisticated regarding the techniques of testing and the analysis of statistics. The days are over when a publisher's editorial board can nod happy approval when someone says in low serious tones that Professor Ho Ho has looked at this program and has pronounced it good. And the same day is also past for the curriculum area specialist and teachers.

Programmed instructional materials probably should be reviewed in professional journals only by people who know how to evaluate testing procedures and testing results. Those who have always known that fast footwork with statistical data has been developed into a high art surely must recognize the engraved invitation to fraud that the spread of programmed instructional materials has issued. Publishers and buyers must set up rigorous validating and statistical interpretative machinery or Gresham's law will surely slow down a remarkably fruitful movement.

The unfamiliarity of the format, the fact that programs are produced by groups of people rather than by a single author, and the amount of expensive testing that is required all conspire to make programmed instructional material more expensive than the traditional textbook. I see no way around this necessary increase in the cost of instructional materials. It is not that a publisher will make a larger profit from the increased price. Rather, it is that there are more people and longer time spans involved. It can cost as high as $2,000 to validate and test a program that has already cost $10 per frame to create. If a program is 4,000 frames long, an honest publisher can have as much as $42,000 tied up before the program is even set in type and manufactured. Put this off against a book where the publisher gives a $2,000 advance and has no further costs until the manuscript is in the house and ready for the printer and you begin to see the magnitude of the financial problem.

Schools, industry, and government are simply going to have to learn to live with the higher costs. Of course, this shouldn't be difficult because a good program comes to them with virtually all of the guesswork taken out and with a kind of warranty that has never before been possible. It is worth paying more for a car that works 99% of the time than would be paid for one that works 10% of the time.

While any revolution is in progress there are always people on the outskirts of town looting the stores and stealing the gold. The revolution in instructional techniques which programmed materials represent will and has attracted its share of despoilers. Publishers, perhaps more than any other single group, must bear the responsibility for limiting such activity. It can be done if publishers temper their desire for quick profit with a serious concern for the long range future of their businesses and the educational health of their nation. They cannot be amoral midwives but rather they must keep alive only the babies who are properly conceived.

PROBLEMS IN PUBLISHING PROGRAMMED MATERIALS

C. J. Donnelly

C. J. Donnelly points out the complex problems and decisions that must be made before one can begin large-scale publishing of programmed instructional materials. He suggests that traditional concepts of textbook publishing are being changed—beneficially and irreversibly—by virtue of the learner-oriented pre-testing that now precedes publication of programmed materials.

The first two major producers of programmed instruction materials were reference book publishers as distinct from textbook publishers. This paper represents the thoughts of one of these two organizations, the TMI-Grolier affiliation, sharing some of its experiences in the publication of programmed materals. As one of the first large-scale publishers, we probably have made one of every kind of publishing decision posed in this field, and have had the opportunity, at least, to make one of every kind of mistake. Perhaps a discussion of our mistakes and non-mistakes would be instructive to those now entering the field.

As Grolier approaches its fourth year of operation, we sense a general maturity overtaking the profession. No longer are words like "astounding," "revolutionary," and "incredible" in the vocabulary of the marketing and publicity functionaries. One can discern an inverse relationship between the ratio of adjectives to nouns in advertising copy and recency of entry into this field; the more recent the entry, the more adjectives.

At the moment, Britannica and TMI-Grolier still account for the majority of programs in print and commercially available. For those who fancy end-to-end statistics, these companies together account for some 138,000 of the 193,000 frames now in print or 1,870 of 2,478 hours of instruction. The Center for Programmed Instruction points out, though, that this picture will change rather significantly this year. For example, twenty textbook publishers have announced plans to publish a total of forty or fifty programs before the end of 1963. There will be about 350 programs in the U.S. Office of Education-sponsored "Programs '63" catalog, replacing "Programs '62," which listed about 100 programs.

Now a few words about the role of the publisher, as I see it. It will be convenient to discuss this in two major subdivisions: (1) the publisher as interpreter to the general public, and (2) the publisher as a businessman.

As interpreter to the general public (and here I include the vast majority of practicing schoolteachers) the publisher necessarily and inevitably is cast in the role of marketing agent. While various organizations, including the U.S. Office of Education, the Center for Programmed Instruction, the National Education Association, the National Society for Programmed Instruction, the American Management Association, the American Psychological Association, and the American Society of Training Directors have most effectively disseminated and promulgated research results, program and machine surveys, and general information in the field, nevertheless, the Educational Sales Division of TMI-Grolier continues to report many unanswered questions at the grass roots level. Like it or not, it would seem that the majority of what teachers will learn about programmed instruction in 1963 will be learned from representatives of the educational publishing industry. A majority of the programs which will be used in the 1963-64 school year will be selected largely on the basis of this information. The publishing fraternity therefore welcomes all possible guidance from institutes and conferences on programmed instruction, and from the guidelines of such organizations as the joint APA-AERA-DAVI Committee.

A few words about the business-end of the publishing process in the programmed learning field should be instructive. It is here that the myriad operational decisions which may appear minor, or even trivial, are made and it is here that the difference between operating at a profit or a loss is determined. (And if it turns out to be a loss, the publisher cannot for long function in his other role as interpreter and "missionary.") Even were the publisher not underwriting the considerable costs of program development, through advance royalty arrangements, long-term sole-source contracts and the like, a good bit of the shareholders' money will still be committed on a risk basis every time a publishing decision is made, and a print order issued. TMI-Grolier alone, in the printing of programs, used 1,000 tons of paper in 1962. (Which is one of the reasons we are actively exploring film techniques.) We also accounted for something like 500 tons of plastic for the relatively uncomplicated, manually-operated, auto-instructional device we call the MIN/MAX.

Once the basic decision to enter the programmed learning field has been made, the following kinds of decisions demand attention: Will one train one's existing staff or acquire a new staff? Will one contact directly the author? Will one contract with a programming source, a company interested in research and development? Will one buy an existing company?

One then begins to identify the marketing objectives preparatory to setting up a distribution apparatus. One must decide whether one is going to be in home-study, in school selling, industrial training, the government market, in international education and in each of these areas, tactical decisions must be made. In home-study, for example, one must consider mail-order, door-to-door distribution, bookstores, tutoring schools, franchised distributors. In the school field one must decide whether to use direct mail, educate and equip an existing sales organization, or create a new one. In the industrial field, should one create a new company, work with an overseas affiliate, or establish a joint-venture operation? Will the United Nations agencies and the various branches of the U.S. Government be the best approach to the international market?

Having decided on one's market, one then begins to select program content. What courses are to be programmed? Will one specialize in mathematics, science, language arts, social studies, or perhaps concentrate on vocational training?

It is also important to analyze curriculum emphasis: modern material, traditional material, or a combination of both? There are, of course, further details such as determining optimum course or program size. There are a lot of 100-frame programs coming on the market now: others of 200, 300, 400, 500 and on up to 8,000 frames.

How will the program be presented? In a machine, in a book, or some other method? If a machine, will it be a machine which uses paper, films, or a tape? If the machine is to use paper, will the program be on 8½″ x 11″ sheets, paper rolls, or paper fanfolds? If the machine is to use film, will it be 8mm, 16mm or 35mm film?

These questions may all sound very prosaic and mechanical but each one of the foregoing decisions generates other decisions. If a machine using paper is chosen, what kind of paper stock should be employed; printed on both sides; perforated paper, white paper, colored paper with matching complementary inks, perhaps, in terms of Angstrom units? If one selects a machine, what will it be required to do? Record responses, analyze responses, branch, count errors, time responses? Will the program be changed on the basis of student responses?

If the programmed text format is chosen, will it be linear or branching? If linear, should it be with or without a mask? If a mask, should it be made of paper or plastic? Will one choose horizontal page-turning, or a vertical arrangment; will the book be turned over to read in the reverse direction? And should the text be a paperback or hard cover with wire or plastic spiral?

There are, of course, options for quasi-teaching machines, which may consist of paper envelopes or boxes, response-reinforcing devices, dye-spot techniques, coated masking techniques, mechanical punching . . . ad infinitum.

Somewhere along the line one must decide whether programs are going to be consumable or non-consumable, and decide whether response devices or preprinted answer pads are to be made available.

Having made all these preliminary decisions, one must begin to procure and sell something, programs and/or machines. Shall they be sold off-the-shelf, will one seek contracts, train programmers? Then comes the marketing strategy. Are the programs to be sold as basal material; should they be sold with ancillary equipment such as laboratory devices? Will teachers' manuals, language tapes, and extra tests be provided?

A decision of increasingly greater importance is the setting up of the pre-publication testing program. Should the testing program be set up within one's own organization or outside? Will the testing be internally financed or in a cooperative venture with a research organization, or with a school? Only after programs are thoroughly tested and revised are they finally ready for publication.

Once programs are published, one's work is not completed. If your marketing results are satisfactory, one can then start worrying all over again: about the next generation machines, the next generation of programming technology, and future instructional technology in general.

What about the publisher's role in the future? To begin with, textbook publishing will never be the same again. Forgetting for the moment that there are four, five, or any other given number of principles of programmed learning, may I suggest that there is one seminal factor which every publisher must now take into account: the learner-oriented pre-testing prior to program publication which is basic to the technique, and which will re-shape much of the textbook author's thinking about his product.

Since programmed instruction has claimed much, has promised much, much is quite properly being demanded of it. If programs can be designed to produce a specific learning objective and can clinically demonstrate its achievement, cannot all other instructional materials—including the bulk of standard textbooks—also be so developed?

As an indication of what the future holds, I would submit the following quotation for your consideration:

> Scientifically constructed materials for learning and for appraisal and diagnosis, in a form so as to be ready-at-hand and constantly-used conveniences for both teacher *and* pupil, should be universally available. There must be an 'industrial

revolution' in education, in which educational science and the ingenuity of educational technology combine to modernize the grossly inefficient and clumsy procedures of conventional education. Work in the schools of the future will be marvelously though simply organized, so as to adjust almost automatically to individual differences and the characteristics of the learning process. There will be many labor-saving schemes and devices, and even machines, not at all for the mechanizing of education but for the freeing of teacher and pupil from educational drudgery and incompetence. Teachers and pupils will cooperate in fascinating efforts to develop further conveniences. The future school will, in consequence, be as much more efficient than the schools of the past as modern industry is more productive than the handicraft of 200 years ago. Will all this make education an industrialized monster, neglectful of human values? That it can never do; the purposes of education would prevent it—and a major service of such devices would be to guide educational effort with ever-increasing clearness and adequacy toward the accomplishment of those purposes.

As the true complexity of educational problems is more understood, the need for ways more easily to handle these yet larger problems becomes greater. So, increasingly it will be necessary (and because more necessary, more likely) that special devices and mechanical aids and an industrial revolution in education will come about.

The foregoing quotation, which to my ear sounds nearly as fresh as though it had been written in 1963, was in fact published in a book by Pressey and Robinson, "Psychology and the New Education," in 1933.

So, to those who might say we're going too fast, perhaps out-running the state of the art, I would reply that we are too slow. If we had had a faster start thirty years ago, many of our recent and current problems and some of our future problems would be behind us. And who knows how much closer we might now be to world peace, prosperity, understanding? But it's idle to speculate on what lost time may have cost us; let us simply not lose any more time.

XII A Point of Transition

Wesley C. Meierhenry

Wesley Meierhenry summarizes the present trends in programmed instruction as reflected in the preceding chapters. With this point of transition he offers some penetrating suggestions for the further developments and future trends in the state of the art.

This chapter, "A Point of Transition," is written from the point of view of programmed instruction as used in the traditional sense. There are some developing conceptions of the word "programmed" as being practically synonymous with the systems approach which is discussed later on in this chapter. There are a considerable number of educational specialists who are referring to programmed instruction as being that type of instruction where the entire sequence may be replicated exactly. In such a definition, the use of television, motion pictures, and similar presentations could qualify as being "programmed instruction." To properly interpret this chapter, the reader should assume that a program is defined as "a sequence of carefully constructed items leading the student to mastery of a subject with a minimal error. The distinguishing characteristics of programming materials is the testing procedure to which they are subjected. Empirical evidence of the effectiveness of each teaching sequence is obtainable from the performance records of students" (Ely, 1963). The point of transition, therefore, is the present state of the art as reflected in the preceding chapters along with suggestions as to possible future trends and developments.

Programmed instruction brings into clearer focus than any other preceding change in education the basic question of the purposes of education in a democracy and the way in which these purposes are developed. The reason for this philosophical confrontation is that the very first element in programmed instruction deals with the clear identification of objectives in some type of behavioral form. Those who deal with programmed instruction, therefore, face the necessity of determining from some sources what should be accomplished in the total educational program as well as how individual bits and pieces of the educational program might be pre-determined and fitted together.

Traditionally, there is a feeling that purposes for a school system grow out of the wishes and desires of the citizens of the local community. Historically, some attempts have been made to bring this question into clear focus. One such is the book by George Counts (1932) entitled "Dare the Schools Build a New Social Order?" The strong opposition with which this thesis was greeted, even in the depths of the depression, is an indication of how antagonistic many people are, including professional educators, to the idea of the school systems playing a carefully calculated role in the renewal or re-direction of our society.

Lest one feel that this resistance to the planned role of schools was true only of the depression days, some recent conferences of educators have indicated a laissez-faire role for the schools. For example, when new directions in education are proposed by someone, there is an immediate question from many as to "whose directions?". The implication is that the schools must wait until there is sufficient crystallization within a given community in order that new directions can be taken.

The basic dilemma may well explain the rapid acceptance of programmed instruction in business, industry, and the military as contrasted with the lack of acceptance in public education to which several writers have referred in earlier chapters. In a business enterprise, the instructional objectives are determined by the firm involved which is responsible to no one except its own Board of Directors. The ease of defining these objectives makes it possible, therefore, to develop training routines which do not raise any basic philosophical questions. Much the same thing is also true in the case of the military where there is a reasonably clear function to be performed by training which does not get involved in the whole matter of public policy.

The development of programs for use in public schools reflects the dilemma which is faced by educational institutions. Courses in mathematics, foreign languages, and other subjects of a similar nature, where the objectives are primarily intellectual and skill acquisition, have received much attention by programmers; on the other hand, the social sciences and, to a degree, the language arts have not had similar efforts. Perhaps this basic difficulty of a philosophy is related to some of the subject matter areas where the lack of agreement as to what constitutes appropriate behavior as a citizen in regard to his local community, the state, the nation, and the world comes into clear focus.

A first and overriding consideration in the field of programmed instruction is, therefore, the basic problem of stating objectives for education beyond general platitudinous statements and to more specifically and clearly state objectives within the context of a dynamic democratic social order. In the preceding chapters, there are a number of indirect references to this problem but not as clear a recognition of it as must be made if programmed instruction is to make much greater contributions.

Programmed instruction is forcing a systems approach to instructional operations. There are varying ways of perceiving and defining a system. A part of the difficulty of definition grows out of the question as to what a system is and what is a sub-system as well as the question as to whether there is such a thing as a closed system. Almost any occurrences, such as political, economic, religious, or other happenings, have implications for "an educational system," Nevertheless, in spite of the difficulty of definition, it is possible to direct the discussion of a school system to individual schools or attendance units within the system to educational programs within each of the systems and on to other more minute sub-systems within the school system. The reason that the whole systems approach is receiving so much attention is that programmed instruction should be viewed and conceived as a part of the system and introduced and utilized in such a way that it does not dislocate other parts of the whole. The systems approach is related to the previous discussion of purposes or philosophy since the development of the sub-systems to be presented by programmed instruction must be conceived as an integral part of a larger system.

A difficulty presented by the systems approach is one of keeping the whole enterprise flexible to meet new demands rather than permitting it to become fixed and static. To a considerable degree, educational enterprises in the past have become too rigid and may do so even with programmed instruction unless everyone connected with the educational enterprise recognizes the need for constant inventiveness, adaptation, evaluation and revision of system components.

The application of the systems approach to social institutions presents greater problems than its application to an engineering problem where the systems idea was first developed. For example, the perception of a system for orbiting a satellite requires provisions for certain contingencies. There must be mechanisms for making adjustments during each stage of the flight of the rocket brought about by a magnitude of forces which can be identified but the extent of them cannot be predicted in advance and, therefore, certain flexibilities must be built into the system. There are, however, two points which can be identified which are fixed. They are the launching pad and the eventual orbiting. Contrasted with these fixed points, however, is a social institution which is an integral part of a cultural environment which is always changing in ways that are difficult to measure. Therefore, social institutions operate in a fluid situation—the various aspects of which are difficult to define at any given moment and where it is difficult to determine the dynamics among the various aspects of the culture. This is not to say that it is impossible for social institutions, such as educational enterprises, to identify and to plot the various forces which play upon them, but it does indicate the necessity for increased research in the social and behavioral sciences. Here again the implications for programmed instruction are clear because of the demand that such instruction be considered as an integrated part of a complex operational system. The proponents of programmed instruction have attacked the problem of stating objectives in behavioral form and certainly have made more progress than has ever been made before in this area.

There is evidence that task analysis has received considerable attention in programmed instruction. The attention grows out of the necessity for studying how a task is performed or should be performed. In the case of new instructional demands, the task analysis calls for considerable specificity on the part of those who are proposing the new educational requirements. For example, the task analysis specialists have every right to require that those responsible for proposing the new instructional sequence verify the task to be performed because the whole programming sequence proceeds from the task analysis and unless the task analysis was done properly the outcome of the training program may be far off the target.

As an integral part of task analysis, there must be a conversion into some type of behavioral objectives. A great deal of activity related to programmed instruction has been in this direction. Programmed instruction has shown the necessity for a departure from loose general objectives to those which can be stated operationally. We are still stifled at the moment, however, by our inability to place educational objectives into some kind of taxonomy and then to transfer the resulting objectives into acceptable behavioral terms. An integral part of the programmed instruction movement has been to give attention to the specific outcomes of instruction, but still more needs to be done.

A further point brought on by programmed instruction is that pertaining to testing and evaluation. In the preceding discussions it has been clear that we are attempting to determine what instruction should accomplish. We are beginning to more nearly define what we hope will be accomplished by instructional procedures, but are now faced with the necessity of developing valid measuring instruments to determine if the objectives have been reached. Although the testing movement has made great strides in the United States in the last one-half century, anyone who has conducted research studies has been struck by the lack of scientific instruments to measure changes which have resulted from specified variables. Programmed instruction presents additional problems of evaluation, such as, should criterion frames also be used as test frames? Should we expect that as learners pursue a program they will be able to perform related tasks other than the precise ones which the program has prepared them to perform? There is also the related question as to whether tests used in programmed instruction have quite different bases and purposes than those used previously. For example, in the field of achievement testing, there is the principle of "preserving the independence of the measure", which means that the individual developing the test questions is aware of what will be taught but does not know specifically what instructional procedures are being, or have been taken. In the case of programmed instruction, there is almost always an insistence that the person developing the test items know exactly what is planned in the programmed sequence. The fact is that these two tests often are prepared by one and the same individual. One has, therefore, a fundamental difference in perspective between the traditional testing approach and what takes place in programmed instruction.

A related question is whether the test or criterion items should be specific in nature, or whether they should be drawn from a family of items, any one of which would be an index as to whether or not the learner would be able to perform the designated objectives. In other words, there is the question as to whether the test items should be as nearly like the frames in the program or whether there was prior activity on the part of both the programmer and the test maker in the specification of objectives related to a family of tasks and thus of test items.

There is still a considerable difference of opinion as to what can be programmed now and what we may eventually be able to program. Opinions range from an extreme that anything can be programmed where the objectives can be stated in behavioral terms to the opposite end of the spectrum to those who believe that, for the present, programming is limited to rather highly specific and narrowly defined tasks. As alluded to earlier, it may well be that part of the difficulty in programming all subject matters is related to a philosophical dilemma rather than a programming difficulty. For example, if it should be possible to define what is appropriate behavior for persons of different races, colors, and creeds to display toward each other, one well might be able to program the appropriate sequences leading to the desired behaviors. The difficulty at the moment is to obtain any kind of universal agreement as to what represents acceptable behavior in various social situations. In the transition period we shall no doubt give much attention to varieties of outcomes which can be brought about by programmed instruction including such possibilities as values, reasoning, and creative thinking.

Much of the activity of experienced programmers has been related to the development of programming from certain theoretical perspectives. A basic dichotomy is said to exist between linear and branching programs. If there were marked differences in the early history of programming they seem to be disappearing somewhat. What does persist, however, is a philosophical difference as to the most economic and propitious means of reaching instructional objectives. This debate is really one related to theoretical considerations, the one pretty generally laboratory based and the other intuitively and empirically based. A resolution of the question may once again be in terms of what are the ultimate objectives, after which the procedural matters may be solved. The conflict perhaps is also related to the question as to whether the approach in programming should be from the "micro" or the "macro" point of view. The one approach would require minute analysis of each stage in the learning sequence whereas the other would start with broad overall objectives and attempt to identify the minimum essentials to be learned. The former might assume the necessity of a large number of small steps, while the latter approach might well concern itself with broad key learnings which could, when synthesized, make possible the performance of the specified learning task.

As programming moves forward there will no doubt be added explorations of various grid and matrix approaches in order to give clues to both the writer and evaluator as to the key points in content and possible inter-relations among them. Some programmers are, in fact, dealing with three-dimensional matrix models as a means of achieving greater scientific analysis of the content. During the transition phase, therefore, we probably will see much more attention being given to the analysis of the subject matter structure by means of various types of models.

One of the most significant contributions made in the programmed instruction movement is that of the inter-relations which must exist among a programming team including content, methodology, and media specialists. It is obvious that someone on the team must be a specialist in the content. The insight of a peculiar kind of scholar is required who is capable of examining his discipline in such a way so as to identify the basic aspects of the structure upon which the mastery of the discipline depends. There is still some difference of opinion, however, as to whether structure does exist at all and, if it does, whether each branch of knowledge has its own unique structure. There are sufficient clues available to lead one to more extensive explorations in this area. For example, in the field of mathematics it now appears that there are three fundamental principles involved, whether one is considering the most elementary number work in the first grade or the highest level graduate course, which are (1) set of numbers, (2) operations on these numbers, and (3) properties of these operations. As simple as these three principles seem to be, it has been only recently that scholars in the field of mathematics have communicated this simplification of the discipline. It is necessary, therefore, to have involved on the programming team a representative of the subject matter area which is to be programmed.

A second equally as significant fact as the discovery of the essential elements of the content are the strategies and methods of teaching them. In the history of programming, more contributions have probably been made at this point than at any other place. Because a great deal of the programming skill has been developed in psychological laboratories, much of the methodology has come from learning theorists. As we move forward, we also are likely to involve the trained and insightful teacher who has intuitively worked out some methods, which have proved to be successful for her. For example, many of the national curricular movements, such as the BSSC biology course, discovered the genius of classroom teachers for advising content specialists on the approaches which will produce the most rapid learning on the part of students. Because most psychologists have worked in laboratory situations, their understandings of the kinds of variables which play upon ordinary classroom situations often are not extensive. It is for these reasons, therefore, that the methodology with which the content is presented in the program requires the joint efforts of both theorists and practitioners.

A second problem of method is related to feedback from the learners. In some preliminary work which has been done there are indications that on material in which the learner has had some prior familiarity, the learner is more able to identify the necessary strategies by which he should learn than is the subject matter specialist. Taken at face value this would seem to be a denial of the premise that the scholar in the discipline is best suited to identify essential elements of content. It must be kept in mind, however, that the studies which have been completed involved subjects who had considerable information about the area even though it was not well organized and in some cases not even known to exist on the part of the subjects. The point is, therefore, that we may well be able to observe learners in order to give us assistance in both the content and presentation decisions, but where the material covers new material we will have to continue to obtain much of our insight from the content specialists.

A third member of the programming team whose role is just now evolving is a person who is a specialist in the identification of the experiences which are needed by learners in order to satisfy the objectives of the programmed sequences. The early history of programs was that they were almost entirely of a verbal nature both so far as the stimulus and response frames were concerned. Perhaps this was to be expected since the specialists in the field of human learning have been concerned primarily with verbal materials although some prominent human learning theorists have attempted to extrapolate findings from animal laboratories and apply them to human learning. The research conducted by learning theorists has emphasized verbal learning and included everything from nonsense syllables to meaningful verbal information. Although the implications of nonsense, meaningful, and serial learnings have implications for regular classrooms, these variables are somewhat limited in terms of the complex learning situations found in classrooms. It is quite evident, therefore, why programs coming from psychology laboratories have been primarily of a verbal type. As programmed instruction moves more and more into the main stream or regular classroom activities, it is quite likely that a much broader range of stimuli will be used in order to produce certain learning outcomes other than verbal ones alone. In this period of transition, therefore, we will be faced with extensive work in the area of media, both for stimulus and response purposes. An individual whose role is that of message designer for all types of media including visual, auditory, and verbal approaches will be needed as a member of the team.

During this period of exploration and experimentation, we are likely to see continued attention given to a wide variety of factors within the programs themselves. One such variable deals with the length of the program. Even though it might be possible to program a semester or a complete course in a subject matter course area, we may well find some obstacles to the adoption of such courses and other approaches will have to be attempted. For example, although it may be advisable or practical to program units of a course or a complete course in a subject matter course area, we may well find some obstacles to the adoption of such courses and other approaches will have to be attempted. We may have to program units of a course or a certain discrete bit of subject matter which is really not in a sequential pattern such as the appropriate role of the slide rule in mathematics or science. A part of this problem might be related to the difficulties inherent in the introduction of any new practice rather than a problem innate in the instructional sequence.

Another variable in programs pertains to the modes of presentation. Considerable success has been achieved for some programmers in the presentation of stimulus material by such a medium as television. Although this practice seems to be quite the opposite of one of the avowed advantages of programmed instruction, there does appear to be some maximum time which most learners require in order to assimilate the stimuli and make appropriate responses. In spite of the known variations of all kinds among learners, they may not be quite so diverse but that a well developed mass presentation may be possible. In addition to television, such approaches as microfilm and motion pictures, including 8 mm, represent alternate possibilities to the traditional text or printed approach to programming. There are other systems being developed which are complex in their operation, frequently including computers, with which much more experimentation can be expected.

Although there has been a good deal of research in the matter of overt vs. covert responses, the period of transition will probably see a better reduction of this problem. Here, as in some of the previous problems discussed, it might be found that the type of responses are related to such matters as the prior experience of the learners and the purposes to be achieved through the instruction.

There also will be studies dealing with such matters as the performance patterns and rhythms of the learners themselves. For example, there are some studies on the physiological aspects of human beings which indicate that there are certain periods of higher productivity as well as lower productivity depending upon the time of the day. This factor may also be related to such matters as fatigue and the length of rest periods taken by subjects pursuing programmed instruction as contrasted with regular school schedules. The above physiological and emotional factors will no doubt be researched much more in the future.

Related to the response phase of programmed instruction is the basic question of reinforcement. Although reinforcement was at one time considered essential, research findings have not always borne out the need for immediate or constant reinforcement. Because the principle of reinforcement has had such a central role in programmed instruction, much more study is needed of this factor.

The use of programmed instruction in public school situations has been quite disappointing. The reasons may lie in a number of directions, some of which may be overcome during this transition period. The first is the increased consideration of the problem of innovation along with diffusion of new products among a large number of users. It is evident now that innovation is a separate phase from diffusion. Programmed instruction is an innovation and various improvements in programmed instruction will also be innovations of a type. Since the innovation of programmed instruction has taken place, we need to focus more on the area of diffusion. Without going into all of the ramifications concerning diffusion practices, the following steps generally seem to be involved:

1. Stimulate interest in programmed instruction through publications, meetings, discussions, and other similar approaches. Along with motivational activities there must be a cultivation of the environment so that changes and modifications are expected by those concerned with the system.

2. Arrange a visit to a situation in which programmed instruction is being used. If this is in the field of education, it should involve teachers talking to other teachers and observing programmed instruction being used with children, so that research results might be checked against actual results as reported by colleagues and the learners.

3. Organize a pilot project. The project should probably be of limited scope initially, so that it can be carried out without involving a large number of other people within the system. This may mean individual units rather than whole courses.

4. Give a great deal of help during the tryout period, including the generous use of consultants and specialists. In spite of the fact that many of the changes involving programmed instruction do not seem complicated, the people using programmed instruction for the first time need a great deal of assistance.

5. Give considerable support and recognition to those individuals participating in the pilot project. This includes individual praise as well as public recognition.

A second problem in the widespread acceptance of programmed instruction may be the difficulty in knowing how to select good programs. Although there have been some criteria developed in regard to this matter, much more still needs to be done. Research results alone, even though statistically significant, are not sufficient to bring acceptance on the part of many people in the field of education. We need to translate these research results into behavioral pattern, so that teachers may recognize the terminology and be able to apply the findings to their own situations.

Publishers of programs have not been too helpful in regard to criteria and standards. In many instances they have little, if any, information about the levels at which this program might be used and the effectiveness of the programs when utilized at the specified levels. In addition, publishers have not supplied related materials which would help administrators and teachers to know how the materials should be used in the classroom. A part of the success of the National Science Foundation in initiating new national curricula is due to putting materials in the hands of teachers and also helping them to learn how to use them. The preparation of teacher handbooks with accompanying illustrative materials will no doubt be attempted in the future as means of showing practitioners how to use programmed instructions.

All of the current work in programmed instruction as well as most educational research in the United States is represented by a behavioristic approach. There is no doubt but that a good deal of progress has been made in the field of instructional technology as a result of such an attack. An appropriate question is whether our current attempts to achieve a break-through leading to an entirely new conception of the learning process are being inhibited by our current models, some of which have been in existence for decades. There is a body of information just now coming from laboratories around the country leading to considerable speculation that the learning act may be much more closely related to chemical changes in the brain and nervous system than had been hypothesized heretofore. The work at the University of Rochester with the planarian worm and the work at the University of California at Los Angeles with electrodes appropriately placed in the brains of primates strongly suggest the thesis concerning chemical changes during the learning act.

There needs to be attention given to the possibility that physiological factors may be much more involved in learning than generally thought to be the case. Chemical changes may give us the explanation as to what actually happens in the learning process and thus not make it necessary to make second hand observations with generally crude tools and instruments.

There can be no question but that programmed instruction has had a greater impact on the field of teaching and learning than has any one innovation in educational history. It is clear from the preceding chapters, as well as this chapter, that we are still a long way from having all the answers that are needed to make final decisions. It appears that we are at the point of an explosive take-off which will involve massive amounts of basic research, developmental activities, and field studies. These will be combined in such a way that the true instructional technology so well postulated in the first chapter of this volume will be well on the way to being accomplished.

APPENDIX A—BIBLIOGRAPHY*

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APPENDIX B
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